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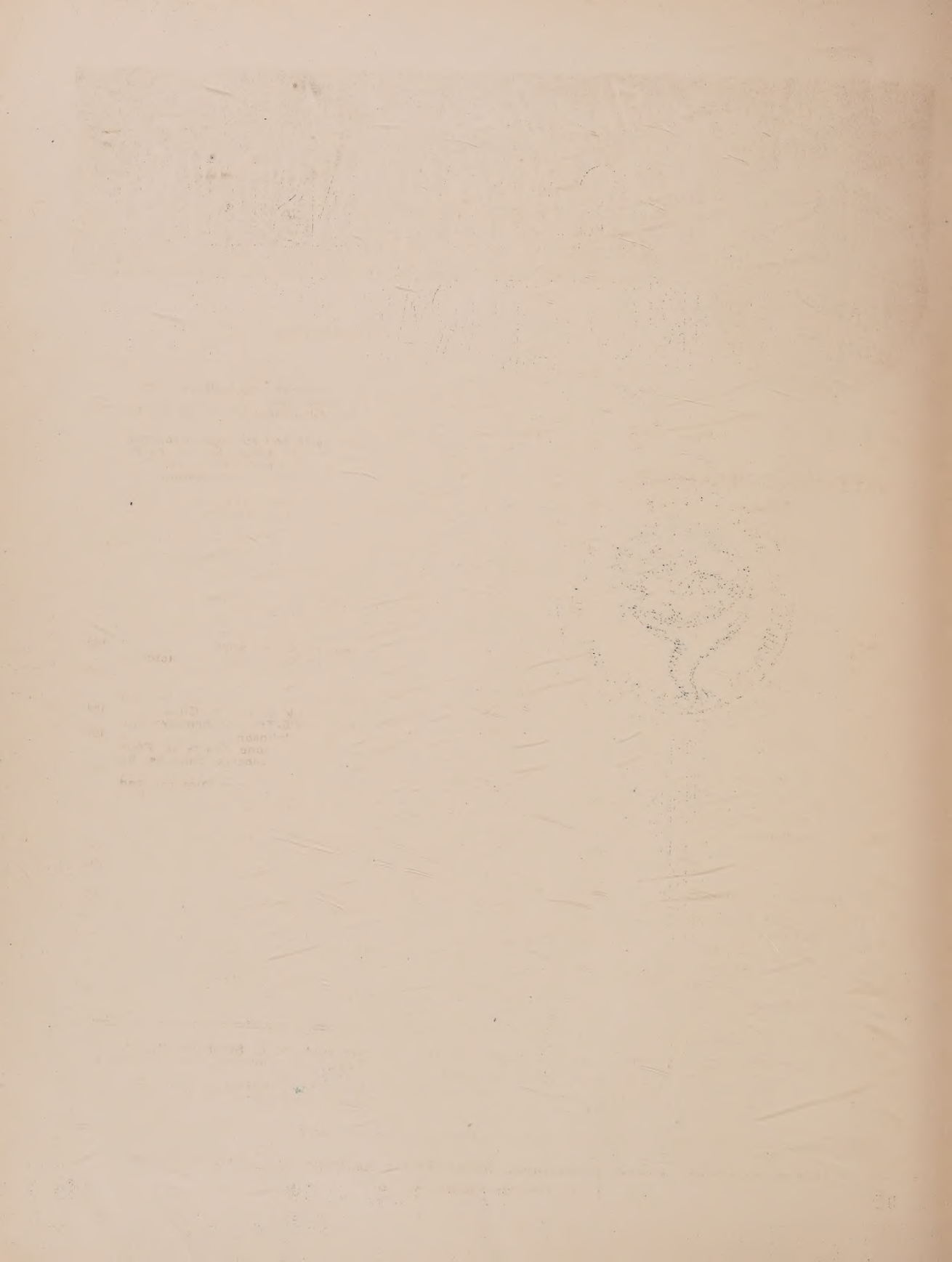

The Journal of THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

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SEPTEMBER-DECEMBER 1949

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A. SHAVITSKY, B.Agr.Sc.
University of Melbourne.

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ARTICLES

BRITISH COMMONWEALTH SPECIALIST AGRICULTURAL CONFERENCE

By DR. I. CLUNIES ROSS

Chairman, Commonwealth Scientific and Industrial Research Organisation

The first British Commonwealth Specialist Agricultural Conference to be held in Australia has recently been concluded at Canberra. The holding of the Conference arose from a recommendation of the British Commonwealth Official Scientific Conference held in London in 1946 that, from time to time, the men responsible for scientific research and development from all member countries of the British Commonwealth should meet together to consider how best to achieve collaboration in scientific research so as to ensure the greatest economy of effort and the dissemination of knowledge for the benefit of all. It was further decided that the best results would accrue from a meeting of the leading active research workers in particular limited fields of scientific endeavour to discuss their common problems and methods of attack on them, to assess the progress being made towards their solution, and to define gaps which still existed.

The Conference just concluded departed somewhat from the original intention that such Conferences would deal with a particular and restricted field of scientific investigation, since, inevitably from the subject matter of it—Plant and Animal Nutrition in relation to Soils and Climate—it covered an extremely wide and complex field.

It may be claimed, however, that, whatever was lost in matters of detail, great benefit was derived from the fact that, for the first time, workers interested in the diverse but inter-related problems not of climate and soils alone, nor of the plant and animal divorced from their environment, but each of these in relation to the other were brought together.

In addition to the formal sessions, in which some seventy papers were read and discussed, delegates were taken on a tour of the south-east of South Australia, through the Western District of Victoria, on to the Goulburn Valley, then through Deniliquin and Griffith (where visits were paid to C.S.I.R.O. research centres), and, finally, by Wagga to Canberra.

Value to Commonwealth

Now that the Conference is over, it is possible to assess something of its significance and value not only to Australia but to other Commonwealth countries. First and foremost, perhaps, it was valuable in forcing so many specialist workers to a realization of the fact that there are no clear-cut boundaries in science, and that, more and more, workers in one field are dependent upon collaboration with and the advances made by others. It was particularly salutary for laboratory workers to appreciate the implications of their work for those engaged in research in the field, and the range and complexity of the problems with which the latter are involved; it was no less salutary for field investigators to

be reminded of their dependence on advances made in the basic sciences for the provision of more effective tools for the conduct of their work. For the Australian and New Zealand delegates, in particular, the Conference was of inestimable value in bringing them into contact with leading investigators of other countries and allowing them to exchange ideas and experience criticism of methods and theories relating to this or that problem.

Most of all, the geniality, frankness and friendliness of all the delegates led to a recognition that, in fact, there is a genuine fraternity of Science, in which knowledge is pooled without reservation for the benefit of all: that, and the fact that personal friendships were made or further cemented and that for so many workers, whether young or old, personal links have been established in practically all the countries of the Commonwealth and the United States from which advice and help will flow in the future.

Recommendation for Future

It is not possible to mention here all the recommendations for future action arising from the Conference, but one may perhaps refer to two or three of these of special significance for Australia. The first related to the necessity for the provision of greater facilities for the accurate evaluation of individual climatic and other variables influencing plant and animal growth and nutrition, if understanding of the importance of soil and climatic factors were to be accelerated. Such facilities, of course, include temperature and humidity controlled chambers for plant and animal work. Secondly, insistence was placed on the necessity for carefully controlled long-term rotation experiments to provide information on the yield and quality of crops and livestock and on their effects on the soil itself. In submitting this recommendation, the Conference had in mind the evidence put forward of the increasing gravity of the depletion of soil fertility throughout all countries of the Commonwealth, and the relation of many current cultural practices to this trend. Finally, it was recognised that both Australia and New Zealand, in view of their complete lack of indigenous high-producing pasture species, have a very special need to interest themselves in the introduction of new plant species, and, to this end, plant collecting expeditions to suitable homoclimes should be organised.

In conclusion, there is cause for gratification that there should have been so many warm expressions of appreciation on the part of all the overseas delegates, not only of the excellent organisation of the Conference, but, no less, of the contribution which Australian workers had made to the understanding of so many of the soil, plant and animal problems which are of concern to other countries no less than to this country.

FOURTEENTH GENERAL MEETING

The Fourteenth General Meeting of the Australian Institute of Agricultural Science will be held at C.S.I.R.O., Canberra, A.C.T., on Tuesday, 21st March, 1950.

AGENDA.

Minutes of Thirteenth General Meeting (Hobart, 10th and 11th January, 1949).

Report of Council for the year 1949.

Report of Editor of Journal for Vol. 15 (1949).

Report of Business Manager for Vol. 14 (1948).

Interim Report of Business Manager for Vol. 15 (1949).

Audited Statement of Accounts and Balance Sheet for year 1949.

Alteration of Articles of Association.

Report of Council concerning the Awards of Merit.

Report of Council concerning the Election of President.

Address of Retiring President, Professor J. R. A. McMillan.

THE ZONAL CONCEPT AND SOIL CLASSIFICATION

By R. SMITH

Introduction

The general agriculturalist may well consider that soil classification is an academic matter which is best left to the specialists working within that rather narrow field. The pedologist, on the other hand, knows the dominant role which current systems of soil classification play in delineating the mapping units in the compilation of soil maps. Now the soil is one of the physical bases of agricultural production and the assessment of its variation as shown on soil maps is one of the more modern techniques used in agricultural research. A direct link thus exists between soil classification and agricultural production.

The purpose of this paper is to trace modern trends in soil classification and to show how one idea, the concept of soil zonality, has played a dominant role in modern systems of soil classification. To understand the origin and development of the zonal concept, a historical approach is necessary.

Russian Origin of the Zonal Concept.

Soil investigators of Czarist Russia were the first to study soils over areas of continental dimensions. Beginning about 1860, a series of brilliant investigators including such names as Dokuchaiev, Sibertsev and Glinka, laid the foundations for the new science of Pedology. The Russians[1] studied soil profiles or soil individuals rather than soil constituents which were studied intensively by the contemporary schools of agricultural chemistry of Western Europe. As a result of their study of soil profiles in widely differing environments the Russians came to the conclusion that in soil formation there are five factors of importance, viz., climate, vegetation, relief, age, and parent rock. The Russians concluded that all soil profiles are formed by the interaction of these five factors. Other ideas were developed about the distribution and classification of soils. These ideas were little known outside Russia until the publication in 1914 of K. Glinka's book, "Die Typen der Bodenbildung, ihre Klassifikation und Geographische Verbreitung." Glinka's book gave a fresh impetus to Western soil investigations, especially in America. Let us look for a moment at its contents:—

Soil Mapping

Firstly, there is the excellent schematic soil map of the Russian Empire, covering European and Asiatic Russia. The Russians had found that the soils of European Russia followed a fairly simple pattern of distribution, the soil zones from north-west to south-east being as follows:—

(1) Tundra soils of the peaty lichen zone

(2) Podzols of the forest zone

(3) Chernozem of the steppe zone

(4) Chestnut coloured soils of the desert steppe zone

(5) Brown soils of the desert steppe zone

(6) Grey soils of the desert steppe zone.

Within this continental pattern each climatic zone is dominated by a particular

R. SMITH, B.Sc. (Agric.), is a Regional Research Officer of the Division of Soils, Commonwealth Scientific and Industrial Research Organisation, at the University of Western Australia.

kind of soil and there is a well marked relationship between these zonal soils, climate and vegetation, e.g., the ashy grey podsol is found under pine forests in a humid climate. Within each broad zone other kinds of soil, less widely distributed, are found, e.g., the rendzina of the podzol zone, the solonetz of the chernozem zone and chestnut coloured soil zones. These minor constituents of the soil pattern were regarded by the Russians as not showing a straightout relationship with climate and vegetation; they were known as intrazonal soils. The Russians recognised horizontal or continental soil zones and, as well, vertical soil zones as seen on the mountain masses of the Caucasus and Central Asia.

Soil Classification

A second and equally important part of Glinka's book is concerned with soil classification. In an historical approach to soil classification, Glinka gives an outline of earlier systems propounded by Thaer, Fallou, Knop, Dokuchaiev, Richtofen, Sibertsev, and Wyssotski before proceeding to his own system. Glinka divides all soils into two great classes, Ektodynamomorphic soils which have been shaped by the external environment and Endodynamomorphic soils which have been shaped by the internal environment. The latter group includes only the rendzina and various skeletal soils, whereas the former embraces all other well defined profile groups known at the time, e.g., laterites, podzols, chernozem, chestnut coloured soils, desert crusts, peat and meadow soils, solonetz and solonchak, etc. Glinka is able to give an excellent picture of the morphology of these various groups. He draws largely on Russian literature but supplements this with references to western sources particularly for a discussion of the lateritic groups.

It is not with the system of Glinka, however, that we are directly concerned here; it is the earlier system of Sibertsev that was adopted by the west. Let us look at it for a moment. Sibertsev summarised his system of soil classification as follows:—

Class A: *Zonal soils. Fine earth humus soils.*

Type:

1. Laterite soils
2. Atmospheric dust soils
3. Desert steppe soils or the soils of the dry steppe
4. Chernozem soils
5. Grey forest soils
6. Turf-podsol soils
7. Tundra soils

Class B: *Intrazonal soils*

Type:

8. Salt soils ("solonetz" and "solonchak")
9. Moor soils
10. Humose lime carbonate soils (Rendzina soils)

Class C: *Azonal, imperfect soils*

Sub-class: *Extra-alluvial soils*

Type:

11. Skeletal soils
12. *Grobe* soils

Sub-class: *Alluvial soils*

13. Stratified alluvial soils.

From a study of this table it is not difficult to see that Sibertsev has allowed mere weight of numbers (in the case of soils, areal extent) to influence his choice of the main categories in his system of classification. In other words, the major class of zonal soils includes those soils which cover a large geographic area, i.e., they are the major constituents of the continental pattern. The major class of intrazonal soils, on the other hand, includes those soils which cover a small geographic area, i.e., they are the minor constituents of the continental soil pattern. In this way, soils, such as chernozem and rendzina, which are fundamentally similar in profile and which therefore

should be placed in the same class and sub-class, are separated in the initial subdivision of all soils. This introduction of a geographic concept into a taxonomic system is one reason why soil classification has remained in a confused state for almost forty years.

The Zonal Concept and American Soil Classification

The classification system of Sibertsev was widely accepted in America, especially following the publication of Marbut's English translation[2] of Glinka's book in 1927. A large amount of detailed information on soil types had been amassed by soil surveyors of the United States Department of Agriculture, but few efforts had been made to devise an all-embracing system of classification for soils of the whole continent. The Americans were delighted with Sibertzev's system. They were able to recognise podzols, chernozem, rendzina, chestnut coloured soils and others among the soils of their own country. The zonal system of soil classification soon appeared in text books on soil and has since held its place in spite of the general agreement among pedologists that soils should be classified on the basis of profile characteristics alone, and not on such external factors as climate, geology, etc.

Recent American text books on soil[4] continue to state that soils may be classified into three major categories:—

1. The order of zonal soils or normal mature profiles which cover large areas and which reflect the influence of climate and vegetation, in their development.
2. The order of intrazonal soils which cover smaller areas and which reflect the dominating influence of some local factor in their development.
3. The order of azonal soils or immature profiles.

Some of the leading American soil scientists recognise that certain aspects of the zonal concept run counter to the principle of classifying soils on the basis of their internal characteristics. In a recent issue of "Soil Science" devoted wholly to soil classification, Thorp and Smith[9] object to the term *normal* soil as signifying a *zonal* soil. They also state that they hope that soil terms indicating zonality or lack of it will eventually be abandoned in favour of terms based on soil characteristics. They point out a number of ways in which the current system of soil classification can be revised, but consider that at present they cannot present a complete and workable system.

It seems clear, however, that current American thought is turning in the direction of the tentative system recently put forward by Leeper[3] who classifies soils as follows:—

1. Mineral soils
2. Peaty soils
3. Parent rock main feature of profile
4. Miscellaneous.

While some may disagree with the placing of classes 3 and 4 in the primary subdivision,[5] there will probably be general agreement in the subdivision of all soils into 1, mineral soils, and 2, peaty soils. Once this principle is accepted it will only be a matter of time before all known groups, and some groups not yet recognised, are fitted into a system of classification based on profile characteristics.

The Zonal Concept and Soil Maps

A second idea, which may not be so obvious at first, grew from the classification system of Sibertsev. This idea springs from the assumption that the soil pattern of the Russian plain is a fundamental one which will be repeated on other continents throughout the world. Theorists argued that the relationship shown to exist between climate and soils on the Russian plain showed that climate was the dominant factor in soil formation and that, therefore, soil patterns on any continent could be deduced from a knowledge of the climate. This idea was strengthened

when it was shown that the soils of North America, which had been studied in some detail, had a similar pattern of distribution to those of Russia. (It is true that the soils of the Pacific Coast of the U.S.A. did not follow this trend at all, but they were regarded as an unimportant exception to the generalisation.) This idea soon resulted in the production of schematic soil maps of the continents of Africa, Australia, South America and Asia. These maps were compiled largely from climatic data supplemented by more or less knowledge of the soils of certain areas.

It is important to emphasise here that these maps really show the approximate distribution of certain known categories of soil. Whether or not they show, even approximately, the actual continental soil pattern can only be determined by many years of survey work. Recent soil survey work in Japan has revealed the existence of the so called *Ando soils*[9] which are formed on recent deposits of volcanic ash. There is little doubt that field surveys in other parts of Asia, in Africa and South America will reveal further soil groups and soil patterns, as yet unknown. As G. W. Robinson[8] points out, it will require at least another fifty years of investigational work before we can hope to classify all the soil groups and soil patterns that exist in the world.

Australian Position

The position in Australia is interesting. Prescott's two soil maps of Australia,[6, 7] provide a valuable initial statement of the soil patterns of Australia. As soil survey work proceeds in all States it will be possible to define these groups more precisely and to place the boundaries between groups more accurately. An interesting recent trend is the discovery that in certain areas the continental soil pattern may be better shown as a unit embracing several soil groups instead of specifying only the dominant group. By this technique, for example, the distribution of the important group of basaltic soils of Eastern Australia can be shown within the podzol zone.

Conclusion

The author has attempted to outline the development of some of the important ideas which lie behind modern systems of soil classification. Soil classification itself is passing through a period of change and there is a good deal of confusion and misunderstanding as between pedologists in different countries. Some fundamental principles are beginning to emerge, however, and these are put forward here for the benefit of the general reader. Several years must elapse before these ideas crystallise and before some general agreement can be reached between pedologists. A longer period of time will elapse before such ideas will appear in textbooks. This article, therefore, can perhaps serve as a progress statement to bridge this gap in time.

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TECHNICAL PAPERS

THE CONTRIBUTION OF LEGUMES TO SOIL NITROGEN ECONOMY IN NEW SOUTH WALES

By HILARY F. PURCHASE, J. M. VINCENT and LAURIE M. WARD

Introduction

No attempt seems yet to have been made to assess directly the possible field contribution of naturally occurring legumes to agricultural soils in Australia. Some indications of nitrogen depletion in wheat belt soils, both from measurements of wheat protein[3] and of soil nitrogen[4] under longer and shorter periods of cropping, have come to our notice in recent years, particularly with regard to the originally fertile soils of the North Western slopes in the neighbourhood of Gunnedah.

Jensen[6] has shown that *Azotobacter* makes no appreciable contribution to soil nitrogen in New South Wales wheat belt soils. He suggested that growth of natural legumes might be sufficient to cover the losses of nitrogen caused by wheat cultivation, but emphasised that a systematic study of the problem would be necessary before any conclusion could be reached.

In connection with a project sponsored by the Rural Bank of New South Wales, observations have been made during 1947 and 1948 on the general distribution of the natural legume species and their development assessed in several agricultural areas under optimum seasonal conditions.

Present Farming Methods in the Liverpool Plains Area

Though details naturally vary between different farmers due to the particular characteristics of the soil with which they are dealing, it may be stated that the general practice has been to crop paddocks either continuously or by growing two, three or four consecutive crops followed by a fallow year. After a period from ten to twenty years (sometimes longer) of such management, and usually only if wheat yields show a tendency to fall off, paddocks are left uncultivated and allowed to regenerate naturally. Full regeneration usually takes from two to three years and such areas later may be brought back into cultivation, or alternatively made to carry their full complement of stock. In relatively few cases, lucerne has been planted on "wheat sick" soil, partly with the idea of building up soil nitrogen; probably it has been quite useful in this respect.

Stubble burning, followed by clean fallowing, has usually been adopted in the past, but more recently a move has been made to avoid stubble burning, and cultivation during a long fallow is now often kept to the minimum necessary to prevent excessive weed growth. These changes in practice relate mainly to soil erosion control problems.

Main Soil Types and Associated Legumes

Observations were made on each of the four main soil types occurring in the Liverpool Plains area and differences in

HILARY F. PURCHASE, B.Sc. (Agric.), and LAURIE M. WARD, B.Sc. (Agric.) are Research Fellows in Microbiology and J. M. VINCENT, B.Sc. (Agric.), Dip.Bact., is Senior Lecturer in Microbiology at the School of Agriculture in the University of Sydney.

the legume species found on each soil type noted. All of these soil types have been used for wheat growing, and in all cases there is evidence of nitrogen depletion in cropped soils.[3]

The results are summarised in *Table I.*

TABLE I.

Soil Type	Main Natural Legume Species
Red brown earths	M.H.D. M.M. M.Lc. (M.Tr. T.G. *Swainsona.*) sp.
Brown and grey gilgai	M.H.D. M.M. (M.Lc.)
Brown chernozem	M.H.D. M.M. M.Lc. M.Tr.
Black chernozem	M.M. (M.H.D.)

Species in brackets occurred in small numbers only.

Key to abbreviations and common names

M.H.D.—*Medicago hispida var. denticulata*—common burr medic (trefoil).
M.M.—*Medicago minima*—woolly burr medic.
M.Lc.—*Medicago laciniata*—cut leaf medic.
M.Tr—*Medicago tribuloides*—barrel medic.
T.G.—*Trifolium glomeratum*—cluster clover.

History of Areas Examined

For each soil type areas representing the following types of treatment were examined with regard to legume development in September, 1948.

1. Land under wheat or other cereal crop.
2. Land under fallow (stubble or cultivated).
3. Virgin land (cleared but never cultivated).
4. Pasture (land which had been previously cultivated but had been allowed to revert to natural pasture for three to ten years).

Wherever possible observations were made on two distinct paddocks, usually on different farms, for each method of cultivation treatment on each soil type.

Assessing the Total Nitrogen Content of Naturally Occurring Legumes

Methods

(a) *Virgin land and pastures*

In each paddock examined the green weight of each legume species was assessed in a 1 x 2 link quadrat for upwards of 60 quadrat placings. The position of the quadrat placement was determined by following a system aimed at sampling the area evenly rather than by random throws.

Top growth was cut off and weighed in every fourth sample, the remaining 75 per cent. of the values being determined by the subjective estimates of experienced observers. The number of samples taken was determined by an initial examination of legume development and was increased with increasing total legume growth.

(b) *Crop and fallow*

Top weight was determined by subjective estimates in a 5 x 5 link quadrat for no less than twenty and usually forty to sixty quadrat placings.

Samples were collected from many areas for determination of percentage moisture and percentage nitrogen in dry weight. These factors were reasonably consistent between different samples and the mean values, 72.4 per cent. for moisture and 3.0 per cent. for nitrogen, were adopted as the best estimates.

The mean top weight in grams per acre multiplied by the factor 2.4×10^{-5} gives the value in pounds of nitrogen per acre, and multiplied by 3.2×10^{-7} gives the value in tons of hay per acre.

Results

Values for top weight of legumes per acre are summarised in *Fig. 1,* the right-hand scale shows the amount of nitrogen in pounds per acre which would be contributed on the basis of 50 per cent. fixation and 100 per cent. fixation.

As would be expected from the type of cultivation practices used there is almost

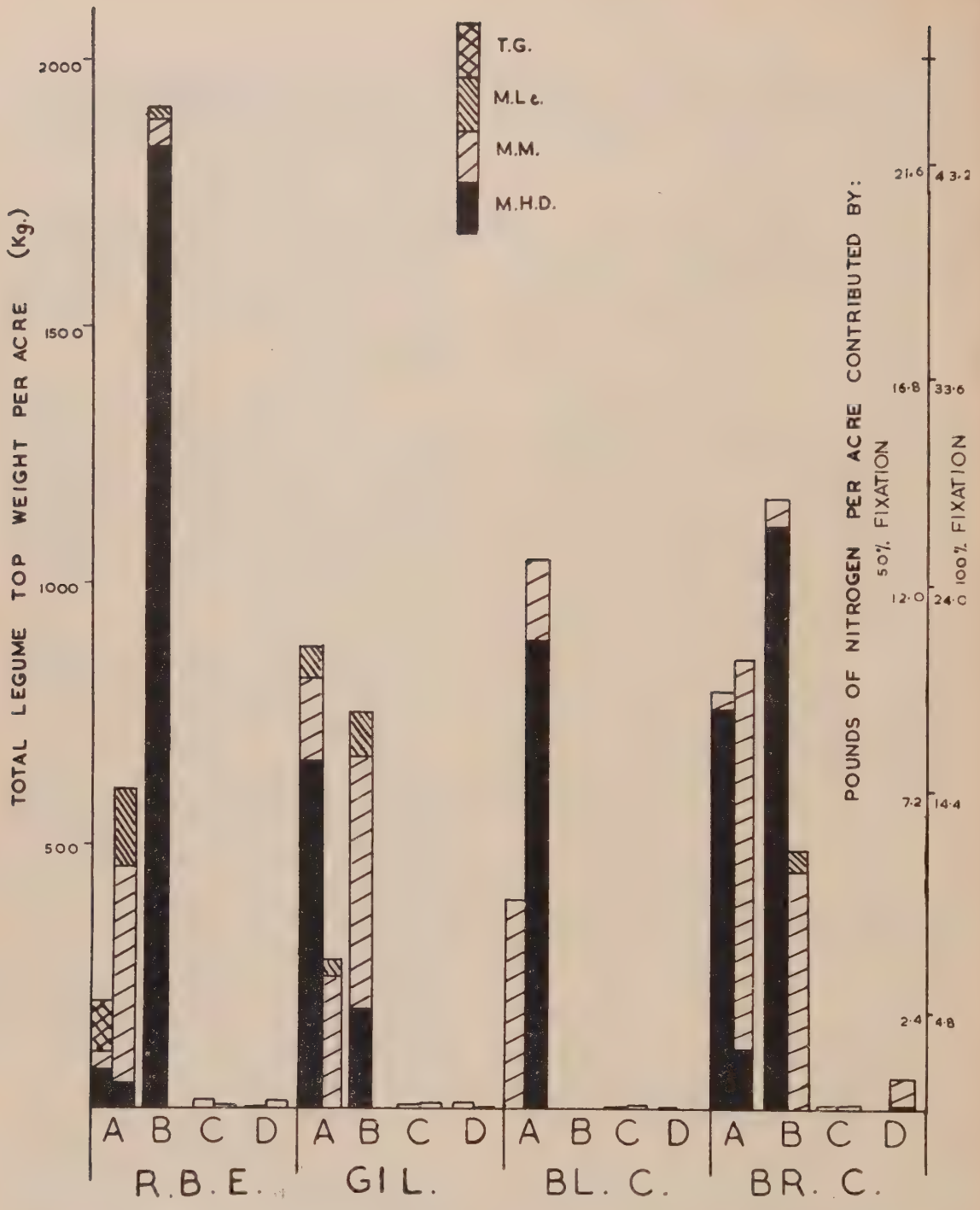

Fig. 1.

Top weight per acre of the main legume species on four soil types and under four types of farming practice.

Abbreviations:

R.B.E.—Red brown earths. Gil.—Gilgai (grey and brown).
Bl. C.—Black chernozems. Br. C.—Brown chernozems.

A—cleared virgin; B—natural pasture at least three years after cultivation; C—cereal crop; D—fallow.

T.G.—Trifolium glomeratum; M.Lc.—Medicago laciniata; M.M.—M. minima; M.H.D.—M. hispida var denticulata.

TABLE II

Cultivation Paddocks—2 crops in 3 years.

Credit	Nitrogen in lb. per acre.	Estimate Based on
In seed (2 crops)	3.6	$1\frac{1}{4}$ bushels per acre
In rain (3 years)	9.0	(6)
From legumes	0.3	Fig. 1.
	12.9	
Debit		
In Grain	37.4	14.76 bushels per acre (1) (12 per cent. protein)*
In burned straw	4.0	(6)
	41.4	

Loss of nitrogen in three years= 28.5 lbs. per acre.
Net loss per annum=9.5 lbs. per acre.

Grazing Paddocks

Credit	Nitrogen in lb. per acre.	Estimate Based on
In rain (1 year)	3	(6)
From legumes	23	Fig. 1.
	26	
Debit		
Nitrogen in one ewe and lamb (carcase and wool)	5.0	(5)

Net gain per annum=21 lbs. per acre.

*An estimate of a general average for the district.

a complete absence of legumes in crop or fallow land, although strong growth, of *Medicago* species in particular, occurs in pasture land. This experience confirmed earlier less detailed, but more widespread, surveys between Parkes and the far North-West.

Nitrogen Balances

For cultivation and grazing paddocks, the balance may be presented as in *Table II*, assuming 100 per cent. fixation of atmospheric nitrogen.

The value 23 lbs. of nitrogen per acre fixed by legumes represents an average calculated from observations made in September, 1948, when an additional one-fifth was added to the observed value to allow for legume herbage grazed before assessment. In many seasons this would approximate the total gain for the year; however, in an exceptional season 50 lb. might be fixed, and the stand observed in a paddock where particular care had been taken to ensure good seeding, suggested a possible further increase of 25 lb.

Discussion

In the figures presented, no account has been taken of losses due to denitrification, leaching or erosion, which might be quite considerable at times, but for which no reliable figures are available.

The nitrogen balance estimates were calculated assuming that 100 per cent. plant nitrogen was obtained by fixation. In soils with a high nitrogen content such as the Liverpool Plains, a figure of 50 per cent. fixation might be more reasonable by comparison with Jensen's results.[7] It is possible that *Medicago laciniata* may not even contribute to this extent, since, for this species, we found a lower than average nodulation in the field and, in laboratory tests, no reciprocal cross inoculation with *Medicago hispida* var. *denticulata*, while isolates from the latter nodulate other common medics.

Since the yield of legumes in crop or fallow paddock is so small, adjusting the figures to a basis of 50 per cent. fixation does not alter the position. However, in average pastures, substituting 11½ lb. of nitrogen for 23 lb. of nitrogen will give a final net gain of 8½ lb. of nitrogen per acre; thus two years of established pasture will give enough nitrogen for one-two subsequent wheat crops.

Where the limitation of cultivation during fallows permits the medics to seed, a more rapid re-establishment of pasture results. A particularly striking example is the property of Mr. C. Watson, of Tichborne, New South Wales, where sufficient legume growth occurs in cultivation paddocks to enable a fair re-establishment of pasture in one year. In this instance, cultivation of the long fallow consists of an initial ploughing in August at the earliest, followed by seed-bed preparation in January.

It is suggested that in a sown pasture the upper limit of legume development might give 1 to 1¼ tons of hay per acre, which is equivalent to 38 to 47 pounds of nitrogen contributed per acre, at the rate of 50 per cent. fixation, and thus sufficient for four to five wheat crops, assuming no extra grazing were allowed.

Conclusions

The survey just completed in the Liverpool Plains area makes it apparent that naturalised legumes are not making any significant contribution to the nitrogen economy of areas continuously under wheat, or with alternating fallow.

Their contribution in natural pastures is likely to be more significant, but the extent of this contribution can only be estimated on existing data as falling between certain limits. From our experience, it would appear that two years' established pasture is necessary to provide enough nitrogen for one wheat crop. Having regard to the slow establishment of the legume population it seems doubtful whether temporary natural pasture in rotation with wheat could be a practical solution. Modification of the clean fallowing practices might reduce the time of regeneration to a considerable extent, suggesting one method of approach to the problem. The alternative and far more dependable method of using symbiotic nitrogen fixation to provide for cereal crops would necessitate the planned sowing of legumes in the crop rotation.

Summary

An account is given of a survey of the distribution and development of natural legume species on agricultural lands in the neighbourhood of Gunnedah. So few legumes survive cultivation practices in crop lands, that very little contribution could be made to soil nitrogen. Given two years for re-establishment it is suggested that sufficient nitrogen for one-two wheat crops might be fixed in two years by the legumes in an average natural pasture.

Natural pastures are at present only rarely introduced into the cropping sys-

tem, and it is quite apparent that nitrogen fixed in such pastures provides insufficient reserves of nitrogen to maintain cropping levels. Since the long time necessary for regeneration is a decided disadvantage, planned sowing of legumes in the rotation may be the most beneficial practical solution to the problem.

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A FIELD RESPONSE OF ROCK-MELONS TO MOLYBDENUM

By R. D. WILSON

Introduction

In the course of a field survey of vegetable crops in the Wetherill Park section of the Sydney Metropolitan Area during November, 1948, a small (about one quarter acre) commercial crop of rockmelons (*Cucumis melo* L.) of the variety Sydney Market was encountered, in which the leaves on many of the plants, which were just commencing to run, were pale green rather than a healthy dark green colour. Tests of the chlorotic intervenal tissue of the leaves gave fairly strong positive reactions with a 1 per cent. solution of diphenylamine in concentrated sulphuric acid. As similar positive tests with this reagent on intervenal leaf tissue had, in the case of cauliflower,[8] lettuce[6] and French beans,[7] been found associated with plants which subsequently responded to molybdenum and, as this crop of rockmelons was in a locality in which whiptail of cauliflowers occurs and within half-a-mile of where a molybdenum response with lettuce was reported,[6] it was decided that an application of molybdenum would be worthy of trial.

Two rows of 30 hills each (2 or 3 plants per hill), in which many of the plants were showing the chlorotic effect, were treated with a solution of crude (45 per cent.) sodium molybdate at the rate of about 1/3 gram of pure sodium molybdate in 6 fluid ounces of tap water per hill, applied to the ground at the base of the plants. The plants were not inspected again until 6 weeks later. All plants in the 60 treated hills were then showing good growth, with a uniformly good spread of the vines, and all leaves were a healthy dark green colour. In the remaining 420 hills in the plot, about 10 per cent. of the vines were very stunted and yellow. Others were slightly chlorotic and the majority apparently healthy, though most of these apparently healthy vines were not making quite as good growth as those in the two treated rows.

Measurement of Responses by Tests with Diphenylamine-Sulphuric Acid on Intervenal Leaf Tissue

In order to secure additional evidence that the improvement in growth was due to the sodium molybdate application, a further experiment, as described below, was carried out, using the diphenylamine-sulphuric acid test on intervenal leaf tissue for measuring the response, as well as visible changes in leaf colour.

Application of Molybdenum

From the untreated portion of the crop, 12 hills, in which the plants were uniformly very stunted and chlorotic, were selected. Before applying any molybdenum, 10 leaves were taken from each of these 12 hills, the leaves selected being about 6 inches back from the tips of the runners. These leaves were subsequently tested (about 24 hours later) with diphenylamine-sulphuric acid. Four of the hills were each watered with 5 fluid ounces of tap water, 4 with 5 fluid ounces of tap water containing 0.1 grams of sodium molybdate, and 4 with the same quantity of tap water containing 0.01 grams of sodium molybdate. The liquid was watered as evenly as possible on to the soil at the centre of each hill at the base of the plants. The sodium molyb-

R. D. WILSON, M.Sc., M.Sc.Agr., is a Plant Pathologist in the Department of Agriculture, New South Wales.

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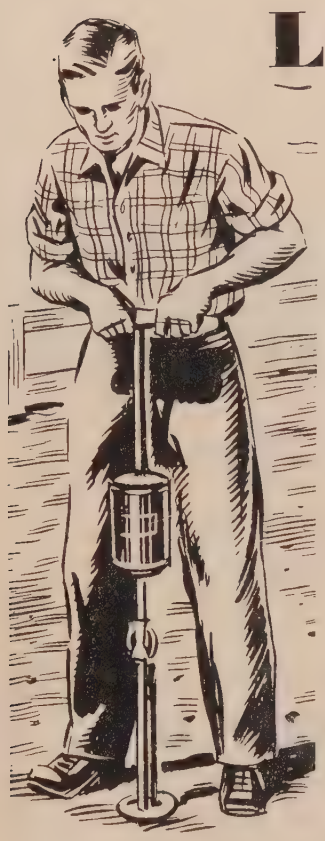

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Chemical Tests on Leaves

As indicated above, leaves were taken, before treatment, for subsequent testing. Further leaves were collected, 7 days after the application of sodium molybdate, these leaves also being about 6 inches back from the tips of the runners. One 6 mm.-diameter disc of leaf tissue was taken from near the edge of each leaf, avoiding the main veins and any necrotic tissue. Two mls. of a 1 per cent. solution of diphenylamine in concentrated sulphuric acid were used for each disc of tissue and a reading of the blue colour intensity made 3 to 5 minutes later as in the case of experiments reported on lettuce.[6] The blue colour produced was matched by eye with prepared standards of nile blue sulphate which ranged from 1 (blue colour just visible) through 2, 4, 8 and further multiples of 2 to 256 (almost opaque) and 512 (opaque), these numbers being proportional to the amounts of nile blue sulphate present. The terms "blue colour just visible," "almost opaque" and "opaque" refer to observations made in the laboratory in daylight on the liquid in $\frac{5}{8}$-inch diameter test tubes. The blue colour intensity designated 256 was approximately the same as that produced by adding 1 ml. of M/100 potassium nitrate to 20 ml. of the test reagent.

Results

Seven days after the application of the sodium molybdate, all plants in the sodium molybdate-treated hills showed a visible improvement in leaf colour (darker green) in comparison with the plants which had received tap water only. The leaves of the plants treated at the higher rate (0.1 grams) appeared to be slightly darker green in colour than those receiving 0.0- grams per hill, but the difference in leaf colour of these 8 hills was not great.

The results of the chemical tests are shown in *Table I.* On the blue colour intensity tests, both sodium molybdate treatments have had a significant effect ($P < 0.01$). Owing to the high degree of variation, especially in the results for the 0.01 gram treatment, the differences between the two sodium molybdate rates —0.1 and 0.01 grams per hill—are not statistically significant.

Soil Reaction

Twelve samples of surface soil collected from near the 12 hills involved in this experiment gave pH readings (glass electrode) ranging from 5.0 to 5.8, with an average pH of about 5.5.

TABLE I

Results of Diphenylamine-Sulphuric Acid Tests on Leaf Tissue

Treatment	Average Blue Intensity per Test	
	Before Treatment*	After Treatment†
Tap water only	129 ± 16.4‡	94 ± 17.9
0.1 grams sodium molybdate per hill	105 ± 13.2	1.0 ± 0.4
0.01 grams sodium molybdate per hill ..	106 ± 12.7	12.5 ± 6.7

*Leaves collected 16/12/48, tested 17/12/48, 10 tests per hill (40 per treatment).
†Leaves collected 23/12/48, tested 23/12/48, 5 tests per hill (20 per treatment).
‡Standard error of mean.

Fig. 1.

Fig. 2.

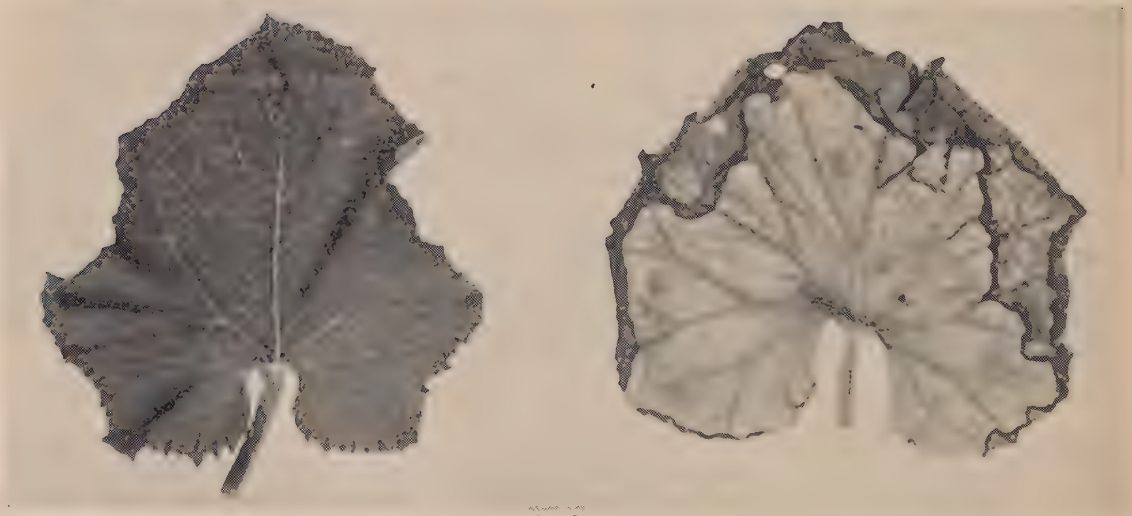

Fig. 3.

Figs. 1, 2 and 3 each show:—
Left: Leaf from vine treated with sodium molybdate.
Right: Chlorotic leaf, with various amounts of marginal necrosis, from untreated vine.

Photos by J. R. Rengger.

Discussion

As far as the writer is aware, no responses to molybdenum, at the deficiency level, have previously been reported for rockmelons or any other members of the botanical family *Cucurbitaceae.* The symptoms observed, however, appeared to be in general agreement with those described for other plants grown in water and sand cultures without molybdenum by Arnon and Stout,[1] Hewitt and Jones[2] and Mulder.[3] By comparing plants treated and not treated with sodium molybdate, it would appear that the main symptoms of molybdenum deficiency in rockmelons are stunting of affected vines, leaf chlorosis and marginal necrosis, especially on the older leaves (*Figs. 1, 2 and 3*).

During December, 1945, the writer inspected two rockmelon crops at Horsley (about five miles west of Wetherill Park), which showed symptoms similar to those reported above. As reported,[4] the random distribution of the disease was, at the time, suggestive of a virus disease. The condition was sufficiently well known in the Horsley area to have received the name of "yellows." At Matcham, in the bean scald section of the Gosford district, white bush marrow was recorded[4] in the same year showing symptoms which, now, would also appear to have been those of molybdenum deficiency.

The results of this experiment add further evidence to that already reported (2, 3, 5, 6, 7, 8) that molybdenum acts as a catalyst in the reduction processes of green plants, and that the diphenylamine-sulphuric acid test on intervenal leaf tissue is of value in diagnosing possible molybdenum deficiencies and in measuring the plant's response to applications of this element.

Summary

Responses to applications of sodium molybdate are reported for a rockmelon crop grown at Wetherill Park, N.S.W., on a soil having a pH of about 5.5. Visible responses were confirmed by tests of the intervenal leaf tissue with diphenylamine-sulphuric acid. The main symptoms of molybdenum deficiency of rockmelons appear to be stunting of affected vines, leaf chlorosis and marginal necrosis, especially of the older leaves.

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THE HORTICULTURAL POTENTIAL, UNDER IRRIGATION, OF SOILS OF THE HIGHLAND AREAS IN THE MID-MURRAY RIVER VALLEY

By K. H. NORTHCOTE

Introduction

Throughout the mid-Murray River Valley, from Nyah in Victoria to Waikerie in South Australia, soils have been developed extensively for horticulture under irrigation. Although many of these soils proved to be highly productive, results were by no means uniform. Beginning in the early 1930s, the older established irrigation settlements, such as Berri in South Australia and Mildura in Victoria, were covered by soil surveys. One result of this work was the accumulation of a considerable body of data relating to horticultural crops and irrigation practices suited to different soil types. Agricultural workers and others interested in these soils largely contributed to this knowledge. The accumulated experience has provided the basis for the development of the more recent irrigation areas, and soil surveys are recognised to be of first importance for defining the soil types and their boundaries. The purpose of this paper is to discuss some of the general principles which arise from the accumulated experience. It is the opinion of the author that such principles can be used to evaluate the horticultural potential of these soils under present methods of irrigation.

The Soils

The soils of the mid-Murray Valley may be considered as belonging to two broad categories which can be differentiated on purely physiographic grounds. These are: (1) Soils of the highland areas, and (2) Soils of the river terraces and flats. This paper is concerned with the former category only.

The highland areas are gently undulating. They are marked by long, narrow sand-rises which are roughly parallel and run in a general east-west direction. In some areas the sand-rises are more pronounced than in others and may be so infrequent as to give the terrain the appearance of a high plain with some few undulations. The sand-rises are separated by interrise flats and depressions of variable extent. The soils of the sand-rises have light, sandy textures and those of the depressions, heavy clay textures. Some of the named, and well-known soils which occur in the highland areas belong to the Murray, Winkie, Berri, Barmera, Moorook, Coomealla, Loveday, and Nookamka soil series.*

Some General Principles relating to Horticulture and Irrigation

Recent experience gained on soil survey work in the Murray Valley, particularly at Loxton and Chaffey in South Australia and Coomealla in New South Wales, indicates that five related factors are concerned. It is the interaction of these factors, one with another, which forms the character of the soil in regard to its possible development. Naturally, different plants, and even varieties of plants, react differently to the soil and to cultural practices.

The success, or otherwise, attending their establishment and development de-

K. H. NORTHCOTE, B.Agric.Sc., is a Research Officer of the Division of Soils, C.S.I.R.O. and is stationed at the Waite Institute, Sth. Australia.

* For descriptions of these soils, see Counc. Sci. Industr. Res Aust. Bull. Nos. 86, 107, 123, 133, 137, and 141.

pends both on the suitability of the soil and the cultural methods used. Unfortunately, there seems to be a paucity of experimental data in this regard. However, experience and observation over a number of years provide some of the background data, but much remains to be done by horticulturists and irrigationists interested in these soils.

At present, it seems that in estimating the horticultural value of these soils under irrigation the following points should be borne in mind:—

(i) the depth of soil above the lime horizons, (ii) the condition or nature of the lime horizons, (iii) the presence of a clay substratum, (iv) the texture of the soil, and (v) the colour of the soil.

It should be emphasized that none of these factors operates independently. They are discussed below, more especially from the soil aspect.

(i) and (ii) *The lime-bearing horizons.*—Perhaps the most important characteristic of most of these soils, and one which seems to have a definite horticultural significance, is the presence of the lime rich horizons. These are the horizons of maximum visible lime concentration in the profile and the soil material both above and below these horizons shows decreasing lime content. Not only does the depth at which these horizons occur seem to be an important factor, but also their nature or condition.

Lime-induced chlorosis is a common ailment, particularly of citrus and apricots, in many irrigation areas. It is interesting to note that Drouineau[6] working with calcareous soils, in France, came to the conclusion that the lime chlorosis of plants does not depend on the quantity of calcium carbonate present in the soil but rather on its degree of fineness and its physical condition. However, a knowledge of the lime content does give some idea of the likely extent of chlorosis. Barthelet and Drouineau[2] consider that it is important to choose the stocks for orchard trees from those varieties which are best adapted to calcareous soils. Earlier, Drouineau[4] showed that both P_2O_5 and K_2O were readily fixed by argilo-calcareous soils even when applied in a highly soluble form; and, later, Drouineau[5] concluded that the fixation of phosphate in such soils depended on the lime content of the sand fraction.

Undoubtedly, the factors involved in lime chlorosis are complex. However, it does seem possible that the availability of plant nutrients may be one of the factors. Experience, in the Murray Valley, strongly suggests that the depth of soil above the lime rich horizon needs to be sufficient to allow full development of the feeding roots without any penetration of the lime zone. It appears that this condition is fulfilled for both citrus and apricots where the lime horizon is at least 24 inches, or better 30 inches, below the surface. Stone fruits other than apricots are not so exacting and about 20 inches of soil above the lime horizon is probably sufficient. Pears can probably reach optimum development with 18 inches of overlying soil. Vines have an extremely wide range in soil conditions, but for optimum growth, at least 18 inches of soil free of stone or medium to large amounts of stony rubble is desirable.

Under irrigation these soils are supplied with large quantities of water far in excess of the amounts which pass through them naturally, as they occur in regions of low rainfall. The average annual rainfall for Mildura is about 10 inches. Since the lime in most of these soils makes for some cementation or compaction of the horizon in which it occurs, there is reason to suspect that the downward penetration of the large quantities of water applied under irrigation will be affected in some way. The ill-health of some citrus growing on the Berri sand at Berri,[7] South Australia, has been traced to a waterlogged condition of the soil immediately above the lime rich horizon. Frequently the waterlogging may be of a

temporary nature and seems to be related to the condition and depth of this horizon. The downward movement of the water is restricted by the lime horizons creating an artificial water-table or soggy soil mass immediately above it. It is emphasized that the waterlogging may be temporary only, but, nevertheless, apparently sufficient to weaken the tree roots and leave them more highly susceptible to the attacks of soil-borne diseases, thus impairing tree health in the long run.

It will readily be appreciated that the condition, that is the degree of cementation or the nature of the rubble content in the lime bearing horizons will help to accentuate or lessen the effect of the formation of a water-table. Where there is a hard cemented lime-pan, the most serious restriction to the downward movement of water would occur. Stirk,[8] working on a Berri sand at Loxton, South Australia, which has a distinct lime-pan at 24 inches, has shown that this is so. The effect of the hard pan was to restrict materially the downward penetration of the water, causing it to spread laterally. On the other extreme, where the lime rich horizon is made up of more or less hard pieces of rubble, stony or angular, having frequent sand channels throughout, it seems unlikely that water penetration is materially affected.

Again, Stirk,[11] working at Loxton, South Australia, with a Loxton sand which has a discontinuous lime-pan between 30 and 36 inches, found that there was no significant down-slope movement of the water. The lime-pan, being discontinuous, had enough soft places or sandy channels through which the water could pass without any great lateral movement. Between these two extremes it seems that the more firmly cemented and continuous the pan, the more likely will be a lateral movement of water associated with temporary water logging. Usually the condition of the lime horizon varies over such short distances in the one soil type, that it cannot be mapped accurately on the soil survey. One criticism of the use of infiltration techniques to evaluate the effect of distinct soil horizons on water penetration is that they are single unit trials only, whereas irrigation involves a much greater concentration of water, a large number of single units, as it were, side by side. Under such conditions it seems more than likely that where a soil horizon restricts downward penetration and causes lateral movement of water in the infiltration trial, there will be some actual down-slope movement of free water; that is, seepage will occur under irrigation.

(iii) *The Clay Substratums.*—The downward penetration of irrigation water is further and more severely restricted by the presence of a clay substratum. The effect of the substratum in restricting water penetration seems to be most severe in those types where it occurs at depths of less than 5 feet; for example, in the Coomealla sandy loam, and loam, and the Loveday sandy loam. A clay substratum possibly occurs fairly extensively beneath these soils at depths greater than 5 feet. For example, at Coomealla, clay appears between 10 and 11 feet on lower slope positions of the smaller Murray sand-rises. The restriction to downward penetration of the water offered by the substratum is possibly the most important factor in the development of the deeper and more permanent types of water-table formed in the Murray Valley areas. Drainage by tile drains has proved successful in the older irrigation settlements as an ameliorative measure following salt damage due to the high and more permanent forms of water-table. The tile drains are most effective when positioned on the clay substratum. However, this is not always practical economics and depths of from 5 to 6 feet have given satisfactory results where the clay substratum is too deep.

(iv) *Texture.*—Seepage and salinity problems are common in the older irriga-

tion settlement of the mid-Murray Valley. While some salinity problems are due to high salt content in the soil type others are caused by the use of excess irrigation water. The latter seems to be true when salt and seepage problems appear on lower slopes somewhere in the transition zone between a light textured soil type, up slope, and a heavier textured soil type, down slope.

It is generally recognised that the amount of water that can be held within the body of a soil varies directly with its clay content, i.e., the lower the percentage of clay (more sandy textured), the lower will be the water holding capacity of the soil, and the freer the drainage, and vice versa. The light textured soils in the Murray Valley, especially the sand types, readily absorb water and pass it on to plants. However, they have only a limited capacity to store water within the soil matrix, due to their low clay content, and consequently, any excess water moves downwards or laterally away from the root zone and is not therefore available to plants.

The normal relationship between soil types and topography in these areas where the lighter or more sandy textured soils occur on the crests of the sand-rises, and in upper slope positions generally causes a banking up of excess water, and seepage results in the transition zone between the lighter and the heavier textured soil types. Further, the lime bearing horizons come progressively nearer the surface, proceeding down the slope of the sand-rise formations, and so accelerate the movement of any excess water in the same direction. The same conditions apply to the heavier textured soils, the sandy loams, and loams, but as the texture increases, so does the amount of water that can be held by the soil. Therefore, larger amounts can be given before seepage becomes a problem. The heaviest types, for example, the Boeil series, are unlikely to show water-table troubles as they have a larger capacity for holding water within the soil body, and infiltration is slower.

Recent work on the infiltration capacities of these soils, Stirk,[10] at Loxton, South Australia, and Bridley,[3] at Coomealla, New South Wales, indicates that they can be separated into the textural classes of sands, sandy loams, and loams in order of decreasing infiltration rate. The results have shown that the sand types, such as Winkie and Murray sands, can be watered most effectively by spray irrigation. By this method a better control can be exercised on irrigation water and should do much to prevent seepage problems in the soil transition zones. The sandy loam and loam soil types having lower infiltration rates, are better irrigated by the furrow method. The length of the furrow run will depend on the texture grade of the soil and can be longer on the loam than on the sandy loam types.

Successful irrigation calls for a balance between the water applied on the one hand and the retentive capacity of the soil and the requirements of the crop on the other. Where water is applied by the furrow method, it seems almost impossible to achieve this balance without some form of deep drainage. Perhaps drainage should be regarded as the natural corollary to irrigation.

Undoubtedly the texture of the soil, the lime rich horizons and the clay substratum, are the controlling factors on the water relationships of these soils under irrigation.

Citrus and apricots, under irrigation, grow most successfully on the lightest textured soil types. Peaches, on the other hand, appear relatively short lived on the very light soil types, such as Winkie sand. Pears yield better on the soils of intermediate and heavy texture such as the Barmera, Matong, and Nookamka series. Vines show the widest range of adaptability. In general, although they develop rapidly on the lighter types, there is some evidence to suggest that more sustained yields and better quality

are obtained from the soils in the middle texture range, such as the Barmera series. Some varieties seem to do better on the heavy textured soils, such as the Nookamka or Boeil series, although they are often slow to start on these heavy types. The relationships between soil type and variety of tree or vine are as yet imperfectly understood. Management and cultural practices are undoubtedly of considerable importance.

(v) *Colour.*—Colour probably has little direct bearing on the health of horticultural crops. However, being an expression of multiple soil factors, such as lime content and possibly salt content, which do exert influences on crops, a quite definite correlation between colour, crop vigour, and health appears to exist. Soil types with dull brown to grey-brown colours, such as the Moorook and Coomealla soil series, often contain small islands of much greyer soil. These grey patches are usually more saline than the surrounding soil areas, vide Thomas,[12] and they may form the foci from which some salinity problems will develop. In these soils, those types with brown to red-brown surface colours support a much wider variety of horticultural crops than do the dull to grey-brown coloured soils. Vines which grow well on both brown and grey-brown soil types, will yield better and more consistently on the brown types. For example, at Coomealla, the brown types, Matong and Dareton sandy loams will yield up to twice as much per acre, under vines, as do the Coomealla series which are dull brown to grey-brown.

A Basis for Evaluating the Soil Types

The points discussed above may be restated from the horticultural standpoint. In all, eight general criteria may be tentatively set down for evaluating these soils in relation to the horticultural crops usually grown in the mid-Murray Valley under irrigation. Halliday and Northcote,[8] first stated two (a) and (d) of these general principles in a slightly different form when defining the land use of soil types at Loxton, South Australia. Recent investigation by Spurling[9] on root development has defined the depths more precisely for vines and figs.

(a) Citrus and apricot require at least 24 inches and preferably 30 inches of soil with sand to sandy loam textures above the calcareous horizons for their optimum growth and longevity.

(b) Stone fruits, other than apricots, require at least 20 inches of soil with sand to sandy clay to loam textures above the calcareous horizons for their optimum growth and longevity.

(c) Pears require at least 18 inches of soil above the calcareous horizons for optimum development. They are better adapted to soils of the intermediate and heavy texture ranges than to the lighter textured types.

(d) Vines require 18 inches of soil free of stone or medium to heavy amounts of rubble for their optimum growth, and grow well under a wide range of soil textures.

(e) Figs will grow well even in soils with medium to heavy amounts of rubble at less than 18 inches in depth.

(f) The brown coloured soils are more productive and less liable to salinity problems than are the dull to grey-brown soils.

(g) The light textured sandy soils should be irrigated by the spray method, especially when they occur on the crests and upper slopes of sand-rises.

(h) Deep drainage is a corollary to furrow irrigation on all except the heaviest textured soils.

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INHIBITION OF AXILLARY GROWTH IN NICOTIANA RUSTICA PLANTS BY CHEMICALS

By B. HOROWITZ

Introduction

There is a large amount of evidence[3, 4] that the content (in per cent.) and yield of nicotine per acre in plants of *Nicotiana rustica* decreases considerably if the axillary growth or the "suckers" are not removed at the proper time. Hence periodical de-suckering is essential in any commercial production of *N. rustica* for nicotine extraction, though it is a costly and tedious manual work requiring 25-30 per cent. of the total production costs of *N. rustica*. Thus the possibility of substituting such a costly treatment by a simple and probably cheaper application of a growth regulator would considerably improve the economic outlook of this production.

The existence of such a possibility was indicated by the work of Beal[1] on Red Kidney Bean, and by Steinberg[5] and Calvert[2] on tobacco.

Steinberg applied powdered compounds to the stem wound by means of a spatula, and liquid compounds with a dropper. Calvert[2] treated the cut stumps of the plants with a paste of various compounds in lanoline. In both experiments some inhibition of axillary growth resulted from treatment with certain growth regulators.

Method

In order to test the possibility of substituting the de-suckering treatment in *N. rustica* by applying a growth regulating compound, a field test was carried out during the summer of 1947 at the Experimental Drug Plant Farm of D.H.A. "Galen" near Cleveland, Queensland. In this test, 90 plants of *N. rustica*, strain 51, var. *Brasile selvaggio*, were formed into nine groups, each consisting of 10 plants selected at random over the whole area of a large plot. The plants were raised from seed sown on July 28 and seedlings transplanted on September 30, 1947.

On December 16, 1947, the plants were in an advanced stage of development and an immediate topping and de-suckering was required. On this date all treatments were carried out. In treatment 1 and in all treatments from 4 to 9, plants were de-suckered and topped by cutting off the upper part of the stalk by means of a knife. Following that, a certain chemical compound was rubbed or smeared into the cut surface of the stalk. Series 1, 2 and 3 received no chemical treatment. Of these, treatment 1—topped and suckered—served as control for treatments 4-9. Treatments 2—topped but not suckered, and 3—not topped and not suckered—are comparable only between themselves as far as the weight of suckers is concerned. Their purpose was to test the effect of topping alone as compared with the absence of topping and de-suckering. Details related to the various treatments are shown in *Table I.*

On December 21, certain changes of shape and colour of the chemically treated cut surface were noticed. This surface, yellowish green at first, became dark brown and contracted, retaining an appearance typical of each chemical treatment to such an extent that identification of treatment received by each plant was

B. HOROWITZ, D.Agr.Sc., formerly an Officer of the Developmental Division of Drug Houses of Australia, is now a Research Officer of the Division of Plant Industry, C.S.I.R.O., at the Waite Institute.

TABLE I

Results of Nicotiana Rustica Treatment with Chemical Growth Regulating Compounds.

Treatment No.	Topped (T) Suckered (S)	Chemical Compound Applied	Number of plants		Fresh weight of two plants in grams Average of 4-10 plants			
			treated	harvested	suckers	leaves	stalks	total
1.	T. & S.	none	10	10	259.0± 40.20	1428.0±62.61	1383.8± 39.60	3040.8± 49.26
2.	T. —	none	10	10	974.4±139.73	1209.8±49.64	1288.0± 38.59	3472.2±186.08
3.	— —	none	10	4	168.0± 56.00	882.0±182.0	1218.0±126.0	2268.0±252.00
4.	T. & S.	Sodium salt 2: 4 Dichloro-phenoxy acetic acid + 15% Tergan 2B.*†	10	6	56.0± 16.17	1194.7±119.16	1409.3± 33.64	2660.0±132.32
5.	T. & S.	2:4 Dichloro phenoxy acetic acid, normal butyl ester†	10	8	126.0± 17.96	966.0± 29.14	1470.0± 46.43	2562.0± 65.48
6.	T. & S.	Alpha naphthalene acetic acid†	10	6	196.0± 56.00	1419.0± 89.03	1465.3± 65.33	2690.6±138.30
7.	T. & S.	Beta naphthoxy acetic acid†	10	10	294.0± 29.09	1203.2±107.90	1355.2± 64.82	2839.2±166.50
8.	T. & S.	2,4,5-Trichloro phenoxy propionic acid	10	10	106.0± 8.19	1204.0± 76.68	1388.8± 33.83	2699.2± 86.18
9.	T. & S.	Ethyl Alpha naphthalene acetate	10	10	252.0± 34.28	1286.4±138.92	1411.2± 24.40	2917.7±160.3

*Tergan 2B is a sodium salt of Di-Butyl Naphthalene Sulphonate.
†By courtesy Timbrol Ltd.

Treatment	Dry weight of two plants in grams Average of four to ten plants harvested				Per cent. in total weight				Alkaloid Content (in per cent.) of		
					suckers		leaves				
	suckers	leaves	stalks	total	fresh	dry	fresh	dry	leaves	stalks	suckers
1.	39.2 ± 5.24	232.4±12.20	252.0± 8.85	523.6±14.41	8.52	7.48	47.0	44.4	7.5	2.1	1.9
2.	137.2 ±14.56	173.6± 9.49	201.6± 4.09	512.4±15.07	28.07	26.80	34.8	33.9	5.6	1.9	1.1
3.	28.0 ±14.0	140.0±28.0	210.0±15.0	378.0±34.7	7.41	7.41	38 9	37.1	—	1.3	1.0
4.	5.83± 1.17	210.0±21.38	238.0±10.3	453.8±19.28	2.10	1.28	44.9	46.2	6.7	1.2	—
5.	17.50± 3.50	171.5±11.91	238.0± 8.08	427.0±12.12	4.92	4.10	37.7	40.2	7.7	1.4	1.2
6.	28.0 ± 8.08	238.0±14.0	238.0±16.58	504.0±29.13	7.28	5.56	52.7	47.2	5.9	1.6	1.1
7.	42.0 ± 4.43	212.8±18.47	218.4±11.36	473.2±24.2	10.35	8.88	42.4	45.0	7.2	2.2	1.2
8.	16.8 ± 2.80	221.2± 9.29	246.4± 3.50	484.4±14.41	3.93	3.47	44.6	45.7	—	—	1.0
9.	42.0 ± 8.08	232.4±16.32	249.2± 2.80	508.9±16.8	8.64	8.25	44.1	45.7	6.7	2.1	1.4

possible. All plants were harvested on January, 9, 1948, and the average weight of fresh and dry suckers, leaves, stalks and total plants was recorded. These data are computed as averages for two plants. The weight of suckers and leaves as percentage of the total weight was also calculated. Finally, the nicotine content (in per cent.) in various parts of the plants was determined for most of the series. All these data are computed in *Table I*.

Results

Fresh and dry weight of suckers

From the data shown in *Table I* it will be seen that in treatments 4, 5 and 8 significantly lower weights of fresh and dry suckers were found than in the control (treatment 1). For treatment 4 the according significance is much higher than for treatments 5 and 8. No apparent effect on the growth of suckers was found in the remaining treatments, in which chemical compounds were applied. Although the weight of suckers in treatments 2 and 3 is not comparable with treatments 4-9, and though only two, very much deviating, results were obtained in treatment 3, a comparison of treatments 2 and 3 confirms the very pronounced effect of topping on the resulting growth of suckers, noticed elsewhere.

Weight of leaves and stalks.

Fresh and dry weights of leaves and stalks of the series in which a chemical compound was used were of the same order as those of treatment 1. Only in treatment 5 significantly lower weights of fresh and dry leaves and in treatment 8 significantly lower weights of fresh leaves were found.

Percentage of suckers and leaves in total weight.

The lowest percentage of suckers in total weight was found in treatments 4, 8 and 5 in an increasing order. The percentage of leaves of the chemically treated series was practically of the same order as treatment No. 1. Only series No. 5 has shown a lower percentage of leaves in the total weight.

The alkaloid content of the chemically treated plants was, on the average, of the same order as those of treatment 1.

Conclusions

In the light of the results obtained, it appears that the application of some growth regulating substances inhibited the axillary growth in *Nicotiana rustica*. This inhibition resulted in a lower weight of fresh and dry suckers, and also in a lower percentage of suckers in total plant weight. This inhibition did not affect adversely the growth of leaves and stalks of chemically treated series, with the exception of treatment 5. The nicotine content of the chemically treated series was not apparently lower than that of the control, in which no chemical compound was used.

Acknowledgments

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I wish also to thank Mr. F. Bray, foreman of the "Galen" Experimental Farm, for carrying out the field work, and Mr. T. D. Adamson, for the Nicotine determinations.

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THE RELATIONSHIP BETWEEN COLOUR AND NECROSIS TO POTATO VIRUS X IN AMARANTHUS GANGETICUS L.

By E. M. HUTTON

Summary

In *Amaranthus gangeticus L.*, a necrotic reaction in the leaves to virus X is favoured by a high proportion of chlorophyll but is suppressed by a preponderance of the carotinoids, particularly carotin. This appears to be associated with a high level of photosynthetic activity in green tissue and a low level in red and yellow.

Virus X, although remaining active in inoculated leaves of *A. gangeticus*, did not become systemic in the plant and so was not recovered from the uninoculated leaves.

Amaranthus gangeticus L., a garden plant, has most of its leaves variegated in green, yellow and different shades of red, although a few are bicoloured and some are of one colour. The range of colour present in the leaves varies from plant to plant. The variegation appears to be genetically controlled, and to result from factors which are able to vary the quantitative relationship between chlorophyll and its associated pigments, carotin and xanthophyll, in different leaf zones.

The Globe Amaranth (*Gomphrena globosa*), an allied species of garden plant with green leaves, has been used as a virus X indicator by Wilkinson and Blodgett.[3] In view of this, it was of interest to test the reaction of the variegated leaves of *A. gangeticus* to virus X. The initial inoculations of this species with virus X resulted in the development of small necrotic areas which appeared to be confined to the green portions of the leaves.

Results from the inoculation of 10 *A. gangeticus* plants with virus X.

In the spring of 1948, an average of 8.6 leaves on each of 10 *A. gangeticus* plants at the flowering stage were hand inoculated in the greenhouse with a necrotic stain of virus X isolated as a result of previous work.[1] The leaves were chosen to cover a complete colour range. Twenty days after inoculation, well developed necrotic ring spots 2-3 mms. in diameter, sometimes with red margins, were visible, particularly in the green areas of the leaves. In addition, a restricted number of indefinite ring spots were noticed in some yellow areas, and reddish non-necrotic lesions in some green areas which were tinged with red. The inoculated leaves were removed from the plants and the petioles placed in water to keep them turgid, and tracings were then made of them, showing the number and location of the various lesions.

When tracing was completed, the leaves were cut up and portions representing each type of lesion and colour were separately inoculated to young *Datura stramonium* plants. All the Datura plants eventually developed severe X symptoms showing that the virus had not been localised by the necrotic reaction in the green areas, and that it had also remained active in all the other variously coloured portions of the inoculated leaves. That the virus did not move from the inoculated leaves was proved when composite samples of the remaining uninoculated

E. M. HUTTON, M.Sc., is a Senior Research Officer of the Division of Plant Industry, Commonwealth Council for Scientific and Industrial Research, Canberra, A.C.T.

leaves of each *A. gangeticus* plant were inoculated separately to Daturas without result.

The results from the tracings of the inoculated leaves are summarised in *Table I*. For convenience, the leaves have been classified according to the proportions present of their two principal colours or groups of colours. Where possible, leaves with similar colour relationships have been grouped vertically in *Table I*. In the table, the mean number of lesions per leaf associated with each colour is placed directly below it. It is apparent from *Table I* that there is a close association between colour and the development of necrotic ring spots. Where green, indicative of a high percentage of chlorophyll, is present in a band or as the dominant colour of a mixture, the production of necrotic ring spots as a result of virus X inoculation is encouraged significantly. The presence of a yellow colour, associated with a high percentage of Xanthophyll, allows the limited development of ill defined ring spots. *Fig.* 1 shows the tracing of a leaf with a large yellow band at the base, and a smaller green band at the tip. The green portion has a relatively large number of definite necrotic ring spots, while the yellow portion has a few poorly defined ones.

It will be seen from *Table I* that the presence of a high proportion of the red pigment carotin results in the suppression of ring spotting and necrosis. In this respect, the results from the last two groups of leaves in each of columns A and B are interesting. With the three leaves in which yellow-red was in greater proportion than green (*Fig.* 2), the red pigment has been in too low a concentration to affect the reaction in the green area. Where green-red was in similar proportion to red (*Fig.* 3), and green-red in greater proportion than red-yellow, the concentration of carotin has been high enough to suppress the necrosis, but not the number of lesions in the green areas.

TABLE I

Relationship between number of virus X lesions and colour in inoculated leaves of A. gangeticus.

	A	B	C	D
No. of leaves	8	5	3	4
Colour	G > Y	R > G	Y > G	R > Y
Mean No. of lesions ..	74 1*	O 16	2* 23	O 3
No. of leaves	8	4	13	2
Colour	G	GR	YR	RY
Mean No. of lesions ..	63	66	6*	O
No. of leaves	3	5	14	3
Colour	YR > G	GR > RY	G > YR	G > RY
Mean No. of lesions ..	O 25	58** O	55 0.5*	39 O
No. of leaves	4	6	2	2
Colour	GR = R	RG > R	G = YR	G = RY
Mean No. of lesions ..	37** O	7** O	31 O	24 O

G = green, Y = yellow, R = red.
GR = green top surface, reddish lower surface; RG = mixture of red and green giving bronze colour; YR = yellow with reddish veins and margins; RY = red tinged with yellow. Proportion of two main leaf colours shown equal to each other or one greater than the other.
*Poorly defined ring spots.
**Mainly reddish lesions sometimes seen best by transmitted light — some necrosis.

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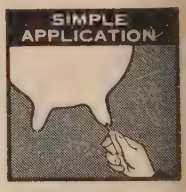

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Fig. 1.

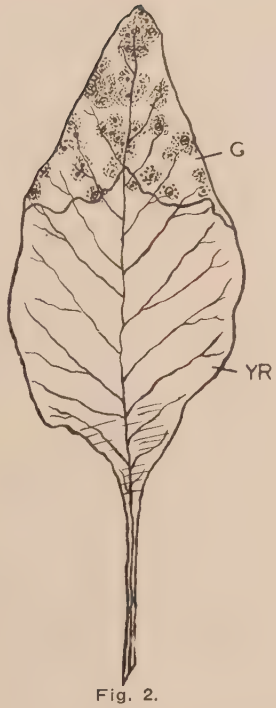

Fig. 2.

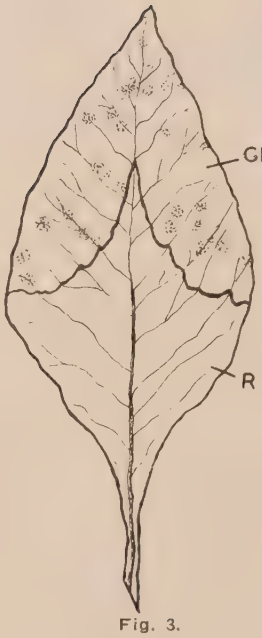

Fig. 3.

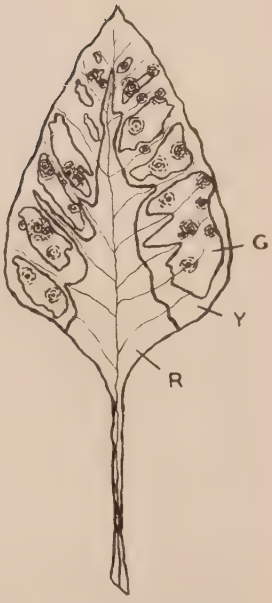

Fig. 4.

Tracings of leaves resulting from the inoculation of A. gangeticus plants with virus X.

In the six leaves with red-green in greater proportion than red, the concentration of carotin has been sufficient to reduce both necrosis and the development of lesions. *Fig.* 4 shows a leaf with a red band at the base, and a yellow band containing green "islands" of tissue at the tip. In this leaf, the development of necrotic ring spots was confined to the green "islands' of tissue.

The relation between photosynthetic activity and the necrotic reaction to virus X in the coloured leaf zones of *A. gangeticus*.

One per cent. diphenylamine in concentrated sulphuric acid (W/V) is used as a test for the presence of oxidising substances, particularly nitrates, in leaf tissue.[3] It can, therefore, be used to indicate the level of photosynthetic activity in leaf tissue, since there is little accumulation of nitrates in bright sunlight when this process is active.

Using a cork borer, 7 mm. discs of tissue, representative of most colours found in *A. gangeticus*, were cut from uninoculated leaves of this species in the greenhouse in bright sunlight. The discs were placed in the depressions of a "spotting plate," and 3 drops of the diphenylamine reagent added to each from a standard 100 ml. dropping bottle. In one to two minutes, the extent of development of a blue colour was noted in the four categories—absent, trace, medium, and intense. No colour indicates absence of nitrates and an intense colour a high concentration. The results obtained are summarised in *Table* 2.

Table 2 indicates a close relationship between nitrate accumulation and leaf colour, green leaves having little, and red and yellow considerable accumulation. On this basis, the green tissues of *A. gangeticus* have a high photosynthetic activity compared with red and yellow in which this process is at a low level. It

TABLE 2

Relationship between colour of leaf tissue and reaction with the diphenylamine-sulphuric acid reagent.

Leaf Colour	% of leaf discs* in the different colour classes				
	Nil	Trace	Medium	Intense	Number of Leaves
G	50.0	50.0	—	—	12
GR	—	66.7	33.3	—	6
R	—	—	44.4	55.6	9
RY	—	—	—	100.0	4
YR	—	—	25.0	75.0	8
Y	—	—	33.3	66.7	6

*Each disc was cut from a different leaf.

is interesting to note in *Table* 2 the effect of the red colour in the green-red leaves, its presence tending to depress the photosynthetic activity of the green tissue.

When *Tables* 1 and 2 are considered together it is apparent that the necrotic reaction to virus X in *A. gangeticus* is favoured by the presence of chlorophyll which has a significantly greater photosynthetic activity than the carotinoids. It is possible that photosynthesis does not occur in some of the yellow and red zones of *A. gangeticus*.

Acknowledgments

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WHEAT YIELDS AND VARIABILITY IN WESTERN AUSTRALIA

(1929-30 to 1946-7)

By F. O. GROGAN

Introduction

In 1941 Gentilli published figures showing the average wheat yields in Western Australian Road Board districts over the period 1929-30 to 1938-39.[1] A longer period was not chosen because the statistical boundaries were reorganised at the beginning of the period and figures for previous years would not have been comparable. As well as the mean yields for the period, the standard deviation from the mean was calculated for each district and this was expressed as a percentage of the mean yield (coefficient of variation). This percentage variability represents the amount by which the district yield in any given year is likely to exceed or fall short of the average.

The concept of variability is important as it will be readily realised that the economic problems could be very different in two districts which had the same average yield over a long period, if one had a regular steady yield always close to its average while the other was subject to very wide fluctuations on either side of the average. It should be appreciated that when the expected variation is referred to in terms of standard deviation, the probability is approximately 2 to 1 against this variation being exceeded in any particular year.

Based on the West Australian Statistician's published annual figures for the average yields for the area harvested for wheat for grain in each district, the figures have been computed by the writer for the eighteen-year period 1929-30 to 1946-47 (inclusive) and when compared with Gentilli's for the ten-year period show interesting changes not only in the average yields and percentage variability for the various districts, but also in the relative positions of the districts one to another with respect to these two criteria.

Comparison of Districts

As comparison of some of the districts with respect to the average wheat yield could be misleading due to varying intensity of cultivation (e.g., a district shown in the Statistical Register as having a high average yield might in reality be one where comparatively little wheat is grown). Gentilli, after discussion with the writer in 1941, decided to group the districts into three regions according to the relative importance of sheep raising and wheat growing in each region.

In his Region III the number of sheep carried in each district was more than twice as great as the number of acres of wheat harvested for grain, i.e., wheat growing was subsidiary to sheep raising. In Region II the ratio varied from 0.9 to 2.0, i.e., sheep raising and wheat growing were both of importance, while in Region I the ratio was less than 0.9, so that wheat growing was definitely the major activity.

Gentilli pointed out that such a broad classification gave rise to minor anomalies and that while the various divisions were shown on the map as separated by firm lines, in reality they merged into one another, while even within one subdi-

F. O. GROGAN, M.Sc., (Agric.), B.A., A.F.I.A., is Acting Principal Investigation Officer of the Bureau of Agricultural Economics, Department of Commerce and Agriculture, Canberra, A.C.T.

TABLE I

Variability and Average Yield per acre—1929-30 to 1946-47.

REGION I

(Ratio of sheep to acres of wheat is less than 2.6.)

DISTRICT	Variability			Yield	
	Rank (on basis of Coefficient of Variation)	Standard Deviation	Coefficient of Variation	Rank (on basis of Av. Yield)	Av. Yield (bus/acre)
Dowerin	1	1.6	13	8	12.3
Wongan-Ballidu	2	1.6	13	10	12.0
Meckering	3	1.7	14	9	12.1
Goomalling	4	1.9	15	7	12.5
Quairading	5	2.2	16	2	13.4
Corrigin	6	1.9	17	16	11.1
Kent	7	1.6	17	24	9.7
Three Springs	8	2.4	18	1	13.6
Dumbleyung	9	2.4	19	5	13.0
Kulin	10	2.1	19	14	11.2
Lake Grace	11	2.1	19	18	10.8
Bruce Rock	12	2.7	20	3	13.3
Carnamah	13	2.6	20	4	13.1
Wickepin	14	2.1	20	20	10.6
Wyalkatchem	15	2.6	21	6	12.7
Kellerberrin	16	2.5	22	12	11.4
Dalwallinu	17	2.5	22	13	11.3
Kondinin	18	2.4	23	21	10.6
Perenjori	19	2.5	24	22	10.6
Narembeen	20	3.0	25	11	12.0
Morawa	21	3.0	27	17	11.0
Kununoppin-Trayning	22	3.7	33	15	11.2
Merredin	23	3.7	34	19	10.8
Koorda	24	3.3	34	23	9.8
Nungarin	25	3.8	41	25	9.3
Mt. Marshall	26	3.7	43	26	8.6
Westonia	27	4.3	52	27	8.2
Yilgarn	28	3.9	52	28	7.5
Mukinbudin	29	3.8	56	29	6.8

REGION II

(Ratio of sheep to acres of wheat is not less than 2.6)

Northam	1	1.4	11	4	12.9
Moora	2	2.1	16	3	13.0
Katanning	3	1.7	17	19	9.9
Brookton	4	1.9	18	15	10.7
Greenough	5	1.8	18	17	10.1
Beverley	6	2.4	19	5	12.9
Victoria Plains	7	2.2	19	8	11.6
Woodanilling	8	1.7	19	22	9.2
Tambellup	9	2.2	20	11	11.3
Northampton	10	2.2	20	13	11.0
Narrogin	11	1.9	20	21	9.4
Irwin	12	2.3	20	10	11.4
York	13	2.6	21	6	12.7
Pingelly	14	2.1	21	20	9.8
Cuballing	15	1.8	21	24	8.6
Toodyay	16	2.9	22	2	13.4
Gnowangerup	17	3.3	23	1	14.6
Wagin	18	2.6	23	12	11.3
Upper Chapman	19	2.5	23	14	10.9
Geraldton	20	2.3	23	18	10.1
Broomehill	21	3.0	25	7	12.1
Mingenew	22	3.2	28	9	11.6
Dundas	23	2.6	32	25	8.2
Esperance	24	2.5	32	26	7.9
Mullewa	25	3.4	33	16	10.4
Phillips River	26	4.4	50	23	8.9

TABLE II

(After Gentilli)

Variability and Average Yield per acre—1929-30 to 1938-39.

REGION I

(Ratio of sheep to acres of wheat is less than 0.9.)

DISTRICT	Variability		Yield	
	Rank (on basis of Coefficient of Variation)	Coefficient of Variation	Rank (on basis of Av. Yield)	Av. Yield (bus/acre)
Wongan-Ballidu	1	10	2	12.07
Kondinin	2	15	5	10.85
Wyalkatchem	3	17	1	12.17
Narembeen	4	19	4	11.60
Kellerberrin	5	19	3	11.85
Kununoppin-Trayning	6	22	6	10.75
Merredin	7	33	7	10.33
Koorda	8	35	8	9.25
Nungarin	9	42	9	8.78
Mt. Marshall	10	49	11	7.85
Yilgarn	11	57	12	7.03
Westonia	12	62	10	7.93

REGION II

(Ratio of sheep to acres of wheat varies from 0.9 to 2.0.)

Quairading	1	8	1	14.52
Corrigin	2	9	8	12.00
Kulin	3	11	9	11.88
Dowerin	4	11	6	12.83
Lake Grace	5	14	10	11.45
Meckering	6	14	7	12.55
Goomalling	7	14	5	13.08
Wickepin	8	15	11	11.14
Carnamah	9	17	2	13.84
Bruce Rock	10	17	4	13.57
Dalwallinu	11	24	12	11.13
Perenjori	12	27	14	10.11
Three Springs	13	28	3	13.59
Morawa	14	30	13	10.40
Mullewa	15	41	15	10.05

REGION III

(Ratio of sheep to acres of wheat is greater than 2.0.)

Dumbleyung	1	10	5	13.50
Kent	2	12	19	10.06
Katanning	3	13	18	10.30
Brookton	4	13	12	11.60
Tambellup	5	13	9	12.09
Beverley	6	15	4	13.76
Gnowangerup	7	15	1	16.57
Wagin	8	16	13	11.23
Moora	9	16	7	13.09
Broomehill	10	16	3	13.84
Esperance	11	17	26	7.80
Cuballing	12	17	25	9.07
Woodanilling	13	17	22	9.55
Narrogin	14	18	23	9.23
Victoria Plains	15	18	10	11.95
Pingelly	16	19	16	10.45
York	17	19	8	13.08
Greenough	18	22	20	9.88
Northam	19	22	6	13.40
Geraldton	20	24	17	10.44
Toodyay	21	24	2	14.01
Northampton	22	25	15	10.80
Dundas	23	28	24	9.09
Upper Chapman	24	28	14	10.85
Mingenew	25	33	11	11.70
Phillips River	26	37	21	9.86

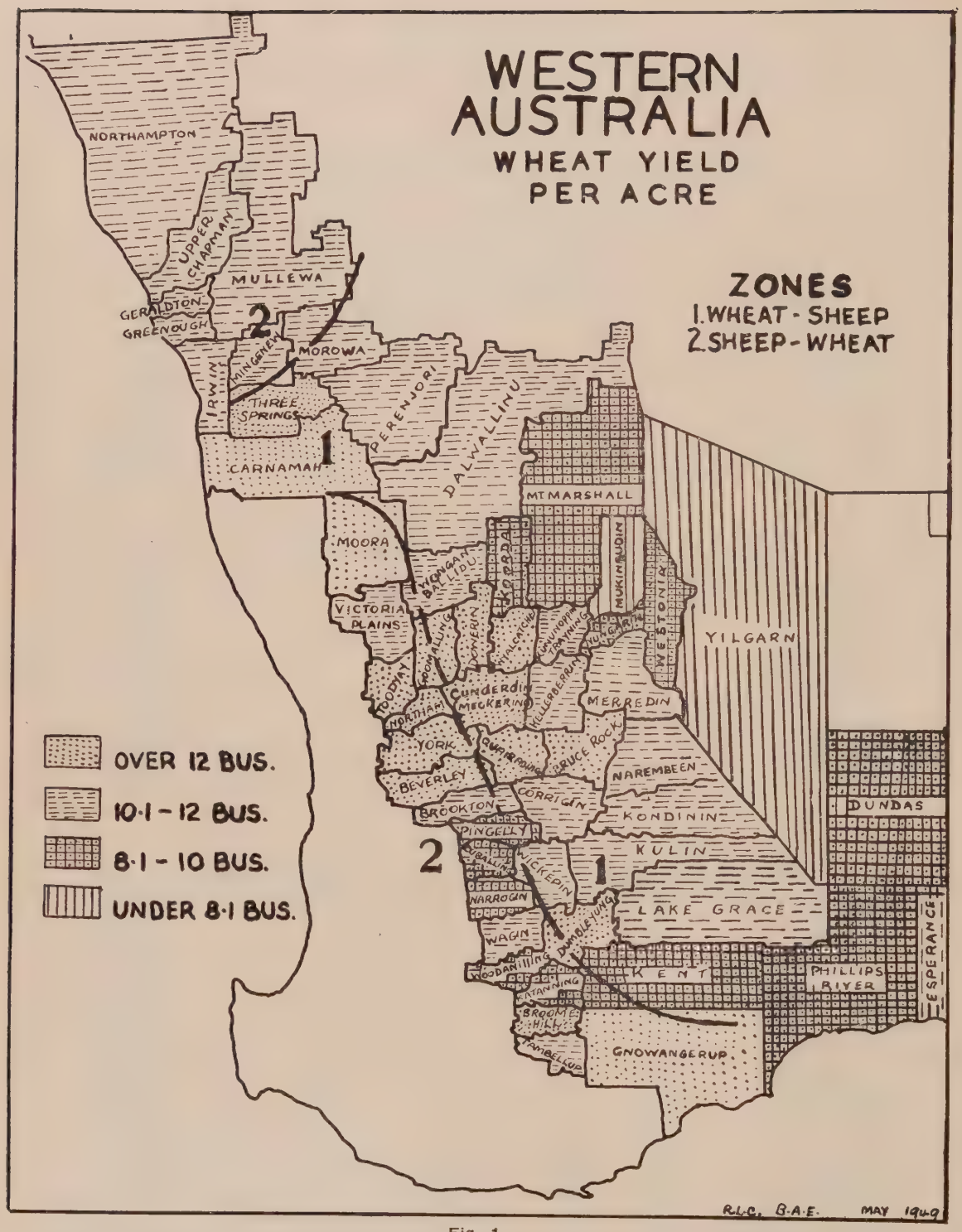

Fig. 1.
Map of South-western Australia showing average wheat yields per acre in the Road Board Districts for the period 1929-30 to 1946-47 (inclusive).

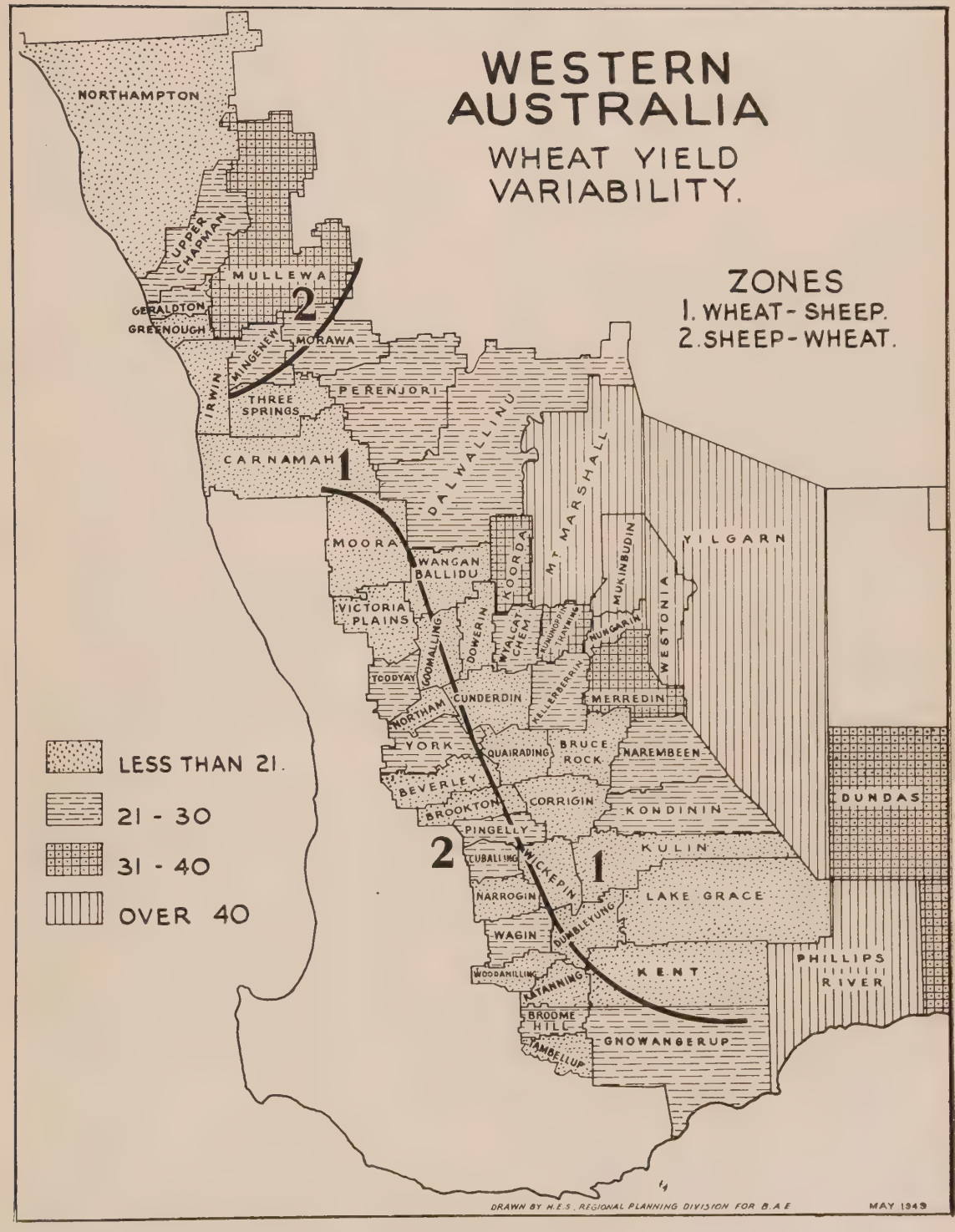

Fig. 2.

Map of South-western Australia showing percentage variability of wheat yield in the Road Board Districts for the period 1929-30 to 1946-47 (inclusive).

vision individual farms might be exceptional, either as to yield, reliability or the pattern of farm management. These difficulties are inherent in mapping of this sort and do not, the writer feels from his knowledge of the area under discussion, invalidate the general picture that is given.

The ratio of numbers of grown sheep carried to the number of acres of wheat harvested for grain has been re-calculated on the basis of the statistical returns for 1946-47, and a striking alteration is revealed as compared with the position as shown by Gentilli. It is now impossible to differentiate on this basis between the districts grouped by Gentilli in Regions I and II. The ratio for the districts in each of these regions varies between 1.4 and 2.0 and they have been grouped together as Region I in the accompanying tables and maps. In what was formerly Region III only Kent and Dumbleyung now show a ratio of less than 2.8 (in each case 2.5) so they have been transferred to Region I which, therefore, is defined as comprising the districts wherein the ratio of sheep to acres of wheat is less than 2.6 while in Region II the ratio is equal to or greater than 2.6.

This relative increase in sheep numbers to wheat acreage has been brought about by a number of factors, some of which arose during the war years, such as labour difficulties, superphosphate shortages, etc., and some of which are probably indicative of a permanent change in farm management due to the gradual improvement of pastures and their spread to districts formerly thought too dry for the successful establishment of subterranean clover.

No attempt was made by Gentilli, nor by the writer, to analyse the causal factors behind the figures. The yields and their variability have been caused by a complex of factors such as soils, rainfall, farming methods, etc., and any sweeping generalisations as to the comparative value of the districts for wheat growing are deprecated.

It might be mentioned that in calculating the standard deviation the root mean square of the deviations has been used (without any correction for size of sample) for comparability with Gentilli's figures and with figures for New South Wales shires published by the Bureau of Agricultural Economics. Attention is also drawn to the fact that, apart from the relative intensity of wheat growing and sheep husbandry, the area sown to wheat in the different Road Board Districts varies within wide limits and makes care necessary in comparing mean wheat yields for the different districts. Particularly is this true in the case of districts on the fringes of the wheat growing zones and, for example, though the mean yield is shown for districts like Dundas, Esperance, Phillips River and Irwin, the area actually sown in these districts in 1946-47 was in each case less than 5,000 acres. In many of the districts, too, including ones with a not inconsiderable total acreage under wheat, the areas sown would be concentrated mainly in the inner portions of the districts. The Road Board Districts concerned, however, have, in the maps, been hatched in toto and a casual glance could give a very misleading impression of the outer limits of the wheat growing zone. Similarly, the districts of Wandering, Williams, West Arthur and Kojonup on the inner boundary which were not listed by Gentilli have been again excluded, though in 1946-47 small areas of wheat were grown in each. These minor anomalies and mapping difficulties are as mentioned elsewhere a corollary of the large size of the statistical units in Western Australia.

It should be noted that from, and including, 1934-35, the Road Board District of Mukinbudin has been added to those listed by Gentilli. This was formed mainly by excision of territory from the area formerly delineated as Westonia.

The calculations in the case of Mukinbudin are therefore based on a thirteen-year period and not on eighteen years.

Further points worth noting are, firstly the very large size of the statistical units in Western Australia tends to level the average yields and prevent any refined analysis being usefully made, and secondly, the soils in the agricultural areas of Western Australia are of an extremely broken and variable nature and this would probably tend to level the average yields between the different districts even if the statistical units were considerably smaller than they are.

Conclusion

Summing up, the following general comments may be made on the data as presented:—

(1) The mean yields and the percentage variability for the eighteen-year period (1929-30 to 1946-47) show, in some cases, marked changes from those computed for the ten-year period (1929-30 to 1938-39). The relative position of the districts, in regard to these factors too, is seen to have altered.

(2) A noteworthy feature is the narrow range within which the mean yield for most of the districts in Western Australia falls (between eight and fourteen bushels). This has the corollary that the potential productivity of any particular farm is more important than the fact that it is situated in a given district because the variable nature of the soils commented on above may cause the yield on particular farms to deviate widely from the district average.

(3) Broadly speaking both yields and reliability tend to fall with drop in rainfall as one proceeds eastwards. On the south-west edge of the main wheat growing region the same falling off is noticeable. Here the cause is rather excessive wetness, particularly on the lighter soil types. Perhaps, as a very rough approximation one may note the following correspondence:—

(a) The lines of 14 in and 20 in. rainfall limit the zone with a variability of less than 20 per cent.

(b) The 14 in. and 12 in. lines limit the zone with variability from 21 per cent. to 30 per cent.

(c) The 12 in. and 11 in. lines limit the zone with variability from 31 per cent. to 40 per cent.

(d) Beyond the 11 in. line the variability is greater than 40 per cent.

An attempt has not been made to similarly relate rainfall and yield, beyond the broad relationship noted above, because of the complications introduced by the effect of the wide variations in soil type on yields.

(4) Over the past decade or so, the agricultural areas show an increasing intensity of sheep husbandry. This has been accompanied by the spread of early subterranean clover pastures which in turn is accompanied by a modified system of ley farming on the lighter soils in the wetter districts where wheat was formerly not grown successfully. The higher and more reliable yields obtained under this system may gradually lead to some reversal of the historical process whereunder wheat growing in Western Australia shifted out from its origins in the wetter districts to the 11-15 in. zone.

Acknowledgments

Grateful acknowledgement is made to Miss S. Murphy and Mr. D. Marriott of the War Service Land Settlement Division, Perth, who checked the calculations and helped prepare the maps.

Reference

1. Wheat Yields and Variability in West Australian Districts 1929-39, Leaflet No. 658, reprinted from "*J. Dept. Agric. West. Aust.*, 17(1): 62, 1941."

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THE EFFECT OF CULTIVATION AND IRRIGATION PRACTICES ON INFILTRATION OF WATER INTO SOME HORTICULTURAL SOILS OF THE MURRAY VALLEY

By G. B. STIRK

Introduction

Recently it was required for purposes of irrigation design to determine the infiltration characteristics of soils in an area proposed for irrigation at Loxton, South Australia. In connection with the proposal to use spray systems upon the lighter textured soils, it was necessary to determine whether rates of water entry into these soils were likely to decrease when the area came under intensive cultivation and irrigation practice. This was checked by comparing the infiltration characteristics of non-irrigated soils with those of soils which had a history of about twenty-five years of cultivation and irrigation. The work was carried out in May, 1946, on sites selected on irrigation areas at Loxton, Berri, and Barmera, South Australia.

Methods

The soils used in the investigation were all light textured, with surface horizons of sand or sandy loam, belonging to the solonized brown soils group. Complete details of the profiles and their mechanical composition and chemical properties have been reported elsewhere.[1]

The rate of entry of water into the soils was measured, using a flooded plot procedure. In this method a metal cylinder 1 ft. in diameter and 6 in. long is pressed into the soil to a depth of 3 in. Pretreatment consists of cultivating the soil to a depth of 2 to 3 in. before setting up the apparatus. Water is applied and maintained on the soil surface by automatic addition through a Mariotte tube from a drum. Periodic readings of a manometer tube attached to the drum give the quantity of water entering the soil in each successive time interval. A reasonably constant minimum rate of water entry (the minimum infiltration capacity) was found to be established within 10 minutes of the commencement of each trial.

Three replicate trials were carried out at each site. Duration of the trials was approximately 40 minutes, except in the Winkie and Berri sand types, where, because of their high permeability, the trials were confined to 20 minutes. The depth of penetration of the water, measured after 24 hours' drainage, was approximately 24 in. for the sandy loam types and 28 in. for the sand types.

The sites were selected so that the non-irrigated and old irrigated sites for each soil type were separated by less than 100 ft. Care was taken to select sites at which the soils representing any one type were in a similar condition with respect to water content. All sites were relatively dry. Because of the comparative nature of the measurements, no attempt was made to correct the final minimum infiltration capacity for effect of lateral movement of water beyond the limits of the test plot. Consequently, the rates quoted in the results, while serving as reliable indexes of the effect of long-term irrigation on water entry, cannot be taken as representing the absolute vertical rates of infiltration for these soils.

A single determination of the apparent density of the surface soils was made at each site by taking a core of definite

G. B. STIRK, B.Sc., is a Research Officer of the Division of Soils, Commonwealth Scientific and Industrial Research Organisation.

TABLE 1

Apparent Density and Infiltration Measurements for Non-Irrigated Soils and Soils Irrigated for About Twenty-five Years.

Soil Type.	Apparent Density of Subsurface		Surface Inches of Water Entering in First 10 Minutes		Minimum Infiltration Capacity	
	Non-irrigated (g/cc.)	Irrigated (g/cc.)	Non-irrigated (in.)	Irrigated (in.)	Non-irrigated (in./hr.)	Irrigated (in./hr.)
Barmera sandy loam .	1.56	1.61	1.5 ±0.15	1.45 ±0.25	7.4 ±1.3	5.7 ±0.9
Berri sandy loam . . .	1.53	1.63	2.3 ±0.45	2.0 ±0.3	11.0 ±1.7	7.4 ±1.4
Nookamka sandy loam	1.56	1.65	2.1 ±0.15	1.95 ±0.3	8.0 ±0.25	6.8 ±1.0
Moorook sandy loam .	1.27	1.45	1.75 ±0.45	0.75 ±0.15	7.9 ±1.3	2.6 ±0.1
Barmera sand	1.48	1.63	2.3 ±0.0	2.0 ±0.3	10.1 ±0.6	8.8 ±2.0
Berri sand	1.46	1.52	2.35 ±0.45	3.6 ±1.6	14.1 ±2.5	20.0 ±9.3
Murray sand	1.49	1.51	3.1 ±0.3	3.4 ±0.65	15.6 ±4.8	17.6 ±1.4
Winkie sand	1.57	1.51	3.1 ±0.3	4.2 ±0.1	17.1 ±2.5	23.8 ±0.6

volume and determining its oven-dry weight. The samples were all taken at depths of 2 to 7 in.

Results

The results of the various measurements are given in *Table* 1. These results with the exception of the apparent density determinations, are the means of three replicates, and standard deviations are included to indicate the degree of variability in the measurements. It appears that irrigation practices have reduced the minimum infiltration capacity of the sandy loam types by approximately twenty per cent., if one exceptional type is disregarded. The sand types on the other hand have not shown this reduction and the minimum infiltration capacity may in fact be rather higher in the irrigated than in the non-irrigated land.

The quantities entering in the first 10 minutes probably reflect the effect of the surface conditions at the different sites upon water entry. In the sand types, the quantities absorbed show the same relation as the minimum infiltration capacities, with higher values for the irrigated than the non-irrigated sites. With the exception of Moorook sandy loam, there is very little difference in the quantities recorded for the sandy loam types,

although the values appear to be slightly greater for the non-irrigated than the irrigated sites. This may indicate that the greater part of the reduction in rate of water entry in these types is due to changed conditions below the surface. Some tendency to plowsole development at a depth of about 9 in. was observed in the field in the sandy loam types, which may account for the lower rates of water entry in these soils.

The rather extreme differences which have been found between the two sites in the Moorook sandy loam, for both the minimum infiltration capacity and the quantity measurement, are thought to be due more probably to site variation than to the effect of long term irrigation upon this soil type.

The higher infiltration rates in the irrigated sand types may be due to the loosening of the subsurface sand by cultivation implements, although the evidence of the apparent density determinations does not support this. There appears to be a slight trend towards higher apparent density in the subsurface soil of the irrigated land in nearly all cases.

The absence of any serious reduction in the minimum infiltration capacity of these types does indicate that the efficiency of irrigating these soils with spray systems will not be affected by future cultivation and irrigation.

Summary

Little change in infiltration characteristics of soils of light texture has resulted from twenty-five years of irrigated culture. The minimum infiltration capacity declined by about twenty per cent. in most of the sandy loam types, but it appeared to have risen slightly in the sand types.

Reference

* Marshall, T. J., and Hooper, P. D.—A soil survey of the Berri, Cobdogla, Kingston, and Moorook Irrigation Areas, and the Lyrup Village District, South Australia. Coun. Sci. Industr. Res., Aust., Bull. No. 86; 1935.

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CONFOUNDING AND FRACTIONAL REPLICATION IN FACTORIAL EXPERIMENTS

By E. J. WILLIAMS

Introduction

The principles and advantages of factorial design in agricultural experimentation are now well known, and factorial experiments are being widely used. In recent years many developments have been made in the theory of factorial design, with a view to facilitating its applications. In a factorial experiment, the number of treatment combinations required increases rapidly with the number of factors in use. Thus, even if each factor is applied at two levels only, the size of the experiment is doubled with each additional factor used. With a large number of factors, the amount of experimental material required for even a single replication may be prohibitive. Besides this, the use of a large number of factors raises the difficulty of accommodating a single replication on a uniform selection of the experimental material.

The device of confounding, that is, of spreading each replication over several relatively uniform blocks in such a way that the comparisons between the blocks correspond to the less important interactions, results in an increase in accuracy for the unconfounded comparisons, and in many cases, greater convenience. Again, the use of only a single replication, with or without confounding, enables the total amount of experimental material to be reduced. In this case, the experimental error, instead of being estimated from differences between replications, is estimated from the comparisons giving high-order interactions, any real effects of which are assumed to be negligible.

Advantages and Disadvantages of Fractional Replication

However, even with a single replication, the amount of material required for an experiment with many factors may be unmanageably large. Six factors each at two levels, requiring 64 plots, or four factors each at three levels, requiring 81 plots, may be considered the upper limit for the general run of agricultural experiments. In exploratory work in a new crop or treatment, the number of factors to be tested may frequently be greater than six, and the problem arises of designing a satisfactory experiment consisting of less than a complete replication. Such a device is known as fractional replication. It will be seen that, with fractional replication, not every treatment combination can be employed. It is therefore necessary to assume, as in confounded or singly-replicated designs, that certain of the interactions do not exist. There are, however, important differences. In an experiment using confounding, large high-order interactions simply remain undiscovered. In a singly-replicated experiment, their presence will increase the estimate of experimental error. In a fractionally replicated experiment, however, their presence may lead to false conclusions regarding the important main effects and low-order interactions, as will be shown below. This limitation of fractionally replicated experiments is not often a serious one in practice; but where there is a possibility that high-order

E. J. WILLIAMS, B.Com., is a Senior Research Officer of the Division of Mathematical Statistics of C.S.I.R.O.

interactions may be large, such designs should be avoided.

We shall confine attention to experiments in which each factor is applied at the same number of levels. When **p** factors are applied, each at **n** levels, a complete replication will require n^p plots. If the experiment is replicated a fraction $1/n^q$, then only n^{p-q} plots will be required. Among the results for these plots, there are only $n^{p-q}-1$ comparisons. However, there are in all n^p-1 treatment effects, including main effects and interactions. It can be shown that each comparison can be interpreted as any one of n^q treatment effects, giving

$$n^q\ (n^{p-q}-1) = n^p - n^q$$

effects in all. The remaining $n^q - 1$ effects are confounded in the fractional replication.

The n^q effects which correspond to the same comparison are known as *aliases* of each other. Since the n^q effects belonging to a set of aliases are indistinguishable from each other, the practical problem in designing fractionally replicated experiments is to arrange that only one member of each set is an effect likely to be important. To do this, some preliminary ideas must be developed.

Groups of Treatments and Effects

We shall designate the different factors by letters *A, B, C* . . . With factors at **n** levels, there are (n — 1) comparisons giving the main effects of a factor *A*, and they may also be represented by *A*. The $(n-1)^2$ interactions of *A* and *B* may be divided into n — 1 sets of n — 1 comparisons, each set being represented by one of the terms $AB, AB^2 \ldots AB^{n-1}$.

Similarly, for three factor interactions, there are $(n-1)^2$ sets of n — 1 comparisons, corresponding to the terms AB^rC^s, where r and s take all values from 1 to n — 1.

The generalised interaction of two interactions is given by the symbolic products of one by successive powers of the other, together with the condition

$$A^n = B^n = \ldots = 1$$

which is a consequence of each factor being at only **n** levels. Thus, with factors at three levels, the interactions of ABC^2 and BCD are

$$AB^2D,\ ACD^2,$$

since

$$A^3 = B^3 = C^3 = D^3 = 1$$

The construction of experimental arrangements with confounding or fractional replication can be dealt with systematically by means of the theory of groups. A set of treatment effects, which has the property that the interaction of any pair of them is also a member of the set, is called a group. The group of all interactions resulting in this way from the interactions of two or more effects is said to be the group generated by those effects. It is seen that the set of all main effects and interactions in any factorial experiment form a group, the *effect group*. Further, it can be shown that, if two or more interactions are confounded in an experiment, so is the group of interactions generated by them. The set of interactions confounded is a sub-group of the effect group, and is known as the *confounded* sub-group.

For example, with five factors, *A, B, C, D,* and *E*, each at two levels, the group of treatment effects is as follows:—

I	*A*	*B*	*AB*	*C*	*AC*	*BC*	*ABC*
D	*AD*	*BD*	*ABD*	*CD*	*ACD*	*BCD*	*ABCD*
E	*AE*	*BE*	*ABE*	*CE*	*ACE*	*BCE*	*ABCE*
DE	*ADE*	*BDE*	*ABDE*	*CDE*	*ACDE*	*BCDE*	*ABCDE*

The element I is known as the identity element of the group, and corresponds, not to a treatment effect, but to the total of all results.

In any arrangement of the treatments in four blocks, each of eight plots, for instance, three interactions are confounded which, together with I, form a group. A confounded sub-group which might be chosen is

$$I \quad ABC \quad ADE \quad BCDE.$$

When the number of blocks is large compared with the number of plots per block, it is convenient to specify the design by means of the treatment combinations belonging to the same block, rather than by the group of confounded interactions. Now the treatment *combinations* (as distinct from the treatment *effects* discussed above) may be represented by lower case letters, as follows. Each treatment combination may be specified by the letters for those factors in which it differs from a given treatment. The set of all treatment combinations is a group which will be called the *treatment group*. The set of all treatments belonging to the same block as the given treatment in a confounded arrangement can be shown to be a sub-group of the treatment group, and is called the *intrablock sub-group*. With factors at two levels, the intrablock sub-group is simply the set of all treatments which have an even number of letters in common with every element of the confounded sub-group. In the above example, the intrablock sub-group would therefore be

1 *abd bc acd de abe bcde ace*

and may be generated by *abd, bc* and *de*.

The treatments would be allocated to the four blocks of any replication as follows:—

As mentioned above, one of the results of fractional replication is that each comparison may be interpreted as more than one treatment effect. The set of aliases of any treatment effect can be most readily identified by the use of the group properties. Any $1/n^q$ fractional replication may be regarded as one of a set of n^q blocks, which would between them make up the complete replication. The group of interactions confounded between such a set of blocks is called the *alias sub-group*. The set of aliases of any effect is the set of interactions of that effect with each element of the alias sub-group.

Application to Confounded and Fractionally Replicated Designs

In agricultural experiments, it is generally assumed that interactions of more than two factors are of little importance, and are likely to be negligible. Methods of confounding which entirely conserve main effects and two-factor interactions, while confounding higher-order interactions, have been extensively studied by Fisher, [2, 3] and others, for it is only such systems as conform to this restriction that are of practical value in research. With fractional replication, the same principle may be applied. For the results to be interpreted without ambiguity, no main effect or two factor interaction may have an alias which is an interaction of less than three factors. This condition implies that all the members of the alias sub-group must be interactions of at least five factors. For example, with eight factors, A, B, C, D, E, F, G, and H, each at two levels, one-quarter replication is possible with an alias sub-group such as

$$I \quad ABCDE \quad ABFGH \quad CDEFGH$$

and it is seen that each main effect and

Block								
I	1	*abd*	*bc*	*acd*	*de*	*abe*	*bcde*	*ace*
II	*a*	*bd*	*abc*	*cd*	*ade*	*be*	*abcde*	*ce*
III	*b*	*ad*	*c*	*abcd*	*bde*	*ae*	*cde*	*abce*
IV	*ab*	*d*	*ac*	*bcd*	*abde*	*e*	*acde*	*bce*

two-factor interaction has as aliases interactions of at least three factors. For example, the interaction *AB* has aliases

AB CDE FGH ABCDEFGH

These considerations show the relevance of studying the possible sub-groups containing no interaction of fewer than three, four or five factors, according as they are to be used as confounding or alias sub-groups. Very general results have been obtained by Bose,[1] and Rao,[7] and particular cases, of importance in practice, are given by Kempthorne.[5] These results are summarised in *Table I.*

For purposes of fractional replication, the block size given in *Table I* is the size of the complete experiment. If it is required to break up the experiment into smaller blocks, further confounding may be introduced. For example, the fourth column of the Table shows that eight factors, each at two levels, may be $\frac{1}{4}$ replicated in 64 plots. The third column shows that, with eight factors, blocks of 16 plots may be used without confounding two or three-factor interactions. Hence the $\frac{1}{4}$ replicated experiment may be carried out in four blocks each of 16 plots.

Table I shows the limits within which fractional replication may safely be used. Even within the rather narrow limits imposed by the conditions described

TABLE I

The Maximum Number of Factors, Each at n Levels, which can be used in Blocks of n^r Plots, without Confounding any Interactions of t or Fewer Factors.

Block Size	The Number (t) of Factors Involved in the Highest Order Interactions Remaining Unconfounded.			
	2	3	4	Possible Fractional Replication
(n = 2)				
4	3	2	2	
8	7	4	3	
16	15	8	5	$\frac{1}{2}$
32	31	16	6	$\frac{1}{2}$
64	63	32	8	$\frac{1}{4}$
(n = 3)				
9	4	2	2	
27	13	4	3	
81	40	10	5	$\frac{1}{3}$
(n = 4)				
16	5	2	2	
64	21	6	3	
(n = 5)				
25	6	2	2	
125	31	6	3	

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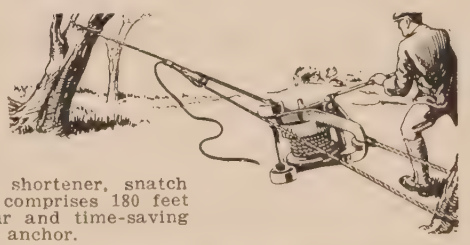

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above, the technique may prove extremely useful. A fraction less than a quarter of a replication is unlikely to be used often in practice.

However, occasions may arise when two-factor interactions are not regarded as important, and all that is required is evidence of the existence of such interactions without the possibility of identifying them. Then smaller fractions may be employed, the alias subgroup including some four-factor interactions. For example, with an experiment consisting of 32 plots, a number of factors from 6 up to 16 may be employed (*Column* 3, *Table* 1), the fraction replicated ranging from $\frac{1}{2}$ to 1/2048 according to the number of factors used. With 8 factors and 1/8 replication, a suitable alias subgroup would be

I ABCD ACEG BDEG ACFH
BDFH EFGH ABCDEFGH

The results given in *Column* 3 also show how many factors may be used with plots of a given size, when complete information on all the three-factor interactions is required.

Multifactorial Design

The number of factors given in *Column* 2 of *Table* 1 is seen to be, not only the number of factors which may be used in confounding in blocks of the given size, but also the number possible in a fractionally replicated experiment, wherein interactions are ignored altogether. Such experiments are known as *multifactorials*.

Multifactorial experiments have the advantage that a very large number of factors may be tested simultaneously with a moderate number of plots. With each factor at **n** levels, and using a number of plots which is a power of **n**, say n^r, it is seen that there are n^r—1 independent comparisons between the n^r results, while the main effects of each factor require n—1 comparisons. Hence there is a possibility of testing $(n^r—1)/(n—1)$ factors in such an experiment and estimating the main effects of each without ambiguity. Plackett and Burman[6] have shown that this possibility can be realized provided only that **n**, the number of levels of each factor, is a prime number or a power of a prime. In practical terms, this means any number of levels less than 6, since more than 6 are never likely to be used. For example, with factors at two levels and 8 plots, the main effects of as many as 7 factors may be tested. If the seven factors are denoted by *A*, *B*, *C*. *D*, *E*, *F*, and *G*, and if any treatment is represented by the factors for which it differs from a given treatment, a possible allocation of treatments to the eight plots is as given in the table below. Under the treatments are tabulated the signs which each treatment result takes in the estimate of the main effects indicated in the left-hand column.

Since these comparisons are mutually orthogonal, the effects of each factor are estimated independently, with equal accuracy.

	1	abcd	abef	cdef	aceg	bdeg	bcfg	adfg
A	—	+	+	—	+	—	—	+
B	—	+	+	—	—	+	+	—
C	—	+	—	+	+	—	+	—
D	—	+	—	+	—	+	—	+
E	—	—	+	+	+	+	—	—
F	—	—	+	+	—	—	+	+
G	—	—	—	—	+	+	+	+

Probably one of the best-known examples of a multifactorial experiment is given by Fisher [4] (Section 35). In this experiment, four components of five spindles are interchanged to determine

which is responsible for winding defective weft. Of the 625 possible combinations, only 25 are used. Of the 24 comparisons among these 25 results, 16, or 4 sets of four, are attributable to main effects, the remainder being attributable to interactions. Only main effects are of interest, however, and these are all determined from independent comparisons.

Practical Example, Using a Quasi-Latin Square

A practical example of fractional replication is a recent experiment on the effect of trace elements and *Rhizobium* strains on the yield of peas, designed for Miss Y. Aitken, of the Melbourne University School of Agriculture. All combinations of five elements, copper, manganese, molybdenum, zinc and an application of wood-ash to supply miscellaneous trace elements are used. Four strains of *Rhizobium* are mixed with the pea seeds before planting. For the purpose of the experimental design, the strains are regarded as the combinations resulting from two pseudo-treatments, each at two levels.

The experiment is thus formally a 2^7 factorial, and requires 128 plots for a complete replication. As has been shown above, half-replication would be quite suitable in this case. Moreover, it is possible to confound high-order interactions. As a square block of ground was to be used, the treatments were laid out in an 8 x 8 quasi-Latin square, so that some interactions were confounded with rows, and others with columns of the square. The double confounding results in there being two groups of confounded interactions which have the alias subgroup in common. The alias subgroup is taken as the seven-factor interaction. Since six and five-factor interactions are aliases of main effects and two-factor interactions respectively, such interactions may not be confounded. However, it is easy to choose sets of three-factor and four-factor interactions which, with the alias subgroup, make up the confounding subgroups. Two such confounding subgroups (which, of course, must have no interaction in common) make up the interactions confounded with rows and with columns. The treatments are denoted by *A, B, C, D, E, F,* and *G,* where absence of *F* and *G* is interpreted as *Rhizobium* strain 1, *F* as strain 2, *FG* as strain 3, and *G* as strain 4.

The confounded subgroup for rows is generated by the interactions

ABC ADE AFG CEG

and is, in full,

I ABDF ABEG DEFG ACEF BCDE BCFG ACDG ABCDEFG CEG CDF ABC BDG AFG ADE BEF.

The intra-row subgroup (that is, the group giving treatments in any row in terms of one of them) is seen to be the same as the even half of the confounded subgroup.

In the same way, the confounded subgroup for columns is generated by

ABG CDG EFG ACE

and is, in full,

I ABCD ABEF CDEF ADEG BCEG BDFG ACFG ABCDEFG EFG CDG ABG BCF ADF ACE BDE.

The intra-column subgroup is the same as the even half of the confounded subgroup.

The quasi-Latin square may now be constructed, from the intra-row and intra-column subgroups. The square actually forms a multiplication table of the elements of the two subgroups. Before randomization, its arrangement is as shown in *Table II.*

The analysis of such an experiment would follow the scheme shown below in *Table IV.* The analysis shows that all main effects and two-factor interactions are estimated without confounding. They are unambiguous as long as five and six-factor interactions are assumed non-existent. The error is estimated with a sufficient number of degrees of freedom

from the mean square for three and four-factor interactions, though it may be overestimated if such interactions are not negligible. The example shows clearly the possibilities of eliciting information in a fairly complex experiment with a relatively small amount of material.

To illustrate the computations involved in the analysis of data from such an experiment, hypothetical results have been given to the different treatments included. A set of 64 values has been taken at random from a normal population with a mean of 5 and unit standard deviation, and has been allotted to the treatments as shown in *Table II.*

The first part of the analysis is to determine estimates of the main effects and two-factor interactions. Each main effect is determined by taking the total of all treatments in which the symbol for that factor occurs, and subtracting the total of all remaining results. Thus, for example, the main effect of *A* is given by

$$-3.75 + 4.23 + \ldots$$
$$+ 4.18 - 4.53 - \ldots$$

The estimates for the two-factor interactions are determined by taking the total of all treatments in which the symbols for both or neither of the factors concerned are involved, and subtracting the total for the remaining treatments. Thus interaction *AF* is given by

$$3.75 + 4.23 - 4.12 - 5.41 \ldots$$
$$- 4.18 - 4.53 + 5.52 + 3.76 - \ldots$$

The sum of squares in the analysis of variance for each main effect or two-factor interaction is given by dividing the square of the estimate by 64. The analysis is set out in full below.

TABLE II.

Layout of Half-Replicated Factorial Experiment in a Quasi-Latin Square

1	*abdf*	*abeg*	*defg*	*acef*	*bcde*	*bcfg*	*acdg*
3.75	4.23	4.12	5.41	4.41	5.24	5.81	7.17
abcd	*cf*	*cdeg*	*abcefg*	*bdef*	*ae*	*adfg*	*bg*
4.18	4.53	5.52	3.76	3.86	6.76	5.05	4.31
abef	*de*	*fg*	*abdg*	*bc*	*acdf*	*aceg*	*bcdefg*
4.67	6.30	3.67	6.32	4.14	6.31	5.46	2.95
cdef	*abce*	*abcdfg*	*cg*	*ad*	*bf*	*bdeg*	*aefg*
5.14	6.18	6.51	3.53	4.76	7.26	4.28	6.07
adeg	*befg*	*bd*	*af*	*cdfg*	*abcg*	*abcdef*	*ce*
3.48	4.63	4.78	6.55	4.92	6.60	5.62	5.53
bceg	*acdefg*	*ac*	*bcdf*	*abfg*	*dg*	*ef*	*abde*
6.12	5.19	4.05	5.66	4.84	5.97	5.18	5.76
bdfg	*ag*	*adef*	*be*	*abcdeg*	*cefg*	*cd*	*abcf*
4.41	5.63	3.73	6.04	5.68	5.07	5.05	6.16
acfg	*bcdg*	*bcef*	*acde*	*eg*	*abdefg*	*ab*	*df*
5.46	3.90	4.73	6.01	5.55	4.86	3.51	6.36

Analysis of the Data of Table II.

TABLE III.

Totals and Estimates of Treatment Effects.

Row Totals.		Column Totals.		Estimates of Main Effects	
1 . . .	40.14	1 . . .	37.21	*A* . .	+ 9.49
2 . . .	37.97	2 . . .	40.59	*B* . .	— 6.45
3 . . .	39.82	3 . . .	37.11	*C* . .	+ 4.49
4 . . .	43.73	4 . . .	43.28	*D* . .	+ 0.53
5 . . .	42.11	5 . . .	38.16	*E* . .	— 2.07
6 . . .	42.77	6 . . .	48.07	*F* . .	— 2.67
7 . . .	41.77	7 . . .	39.96	*G* . .	— 4.19
8 . . .	40.38	8 . . .	44.31		
Total	328.69	Total	328.69	..	..

Estimates of Two-Factor Interactions.

AB	+ 0.27	*BD*	— 9.81	*CG*	+ 5.61
AC	+ 12.33	*BE*	— 6.17	*DE*	— 11.03
AD	+ 0.73	*BF*	+ 0.27	*DF*	— 5.71
AE	— 9.07	*BG*	— 1.65	*DG*	+ 1.45
AF	— 1.83	*CD*	+ 6.49	*EF*	— 22.83
AG	+ 10.81	*CE*	— 0.67	*EG*	— 9.83
BC	+ 6.23	*CF*	— 1.59	*FG*	— 7.39

TABLE IV.

Analysis of Variance.

Source.	Degrees of Freedom.	Sum of Squares.	Mean Square
Rows	7	3.0061	.4294
Columns	7	13.1114	1.8731
Main Effects	7	2.8293	.4042
Two-factor Interactions	21	22.4438	1.0688
Unconfounded Three-factor Interactions (error)	21	23.2330	1.1063
Total	63	64.6236	..

Standard error of estimate of main effect or two-factor interaction $= \sqrt{64 \times 1.1063}$.
$= 8.41$.

Summary

When a factorial experiment is carried out using a large number of factors, it is often not practicable to do a complete replication of all the treatment combinations. In such a case, it is necessary to resort to fractional replication.

Fractional replication enables the amount of experimental material used to be reduced, but it has the disadvantage that the treatment comparisons cannot be interpreted without ambiguity. If a factorial experiment is replicated 1/k, each treatment comparison will have k different possible interpretations in terms of treatment effects.

The construction of confounded and fractionally replicated designs is studied systematically, using group theory. Results are presented showing the maximum number of factors which can be employed for a given size of experiment without confounding interactions of fewer than 3, 4 or 5 factors.

As a practical example, a half-replicated experiment is described. This experiment uses 64 plots which are laid out in an 8 x 8 square. High-order interactions are further confounded between the rows and columns of the square.

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CONTROL OF ROOT-KNOT NEMATODE IN TOMATOES BY SOIL FUMIGATION

The following experiment reports the control of root-knot nematode (*Heterodera marioni*) (Cornu), Goodey, by soil fumigation with D-D*. The experiment was conducted at Red Cliffs, Victoria, on an area of Barmera Sands[1] on which tomatoes had been grown for several successive seasons. The nematode infestation of the soil was heavy, as shown by the fact that in the previous season 85 per cent. of the 607 tomato plants grown on the area showed severe root galls.

The general design of the experiment was a 4 x 4 latin square repeated 5 times with the following treatments:—

Treatment 1: Seedbed fumigated. Plot fumigated.

Treatment 2: Seedbed fumigated. Plot untreated.

Treatment 3: Seedbed untreated. Plot fumigated.

Treatment 4: Seedbed untreated. Plot untreated.

Each plot was 15 ft. by 9 ft. and contained 9 plants spaced 3 ft. apart in rows, with 5 ft. between the rows.

The variety Pan America was chosen for the experiment because of its proved resistance to fusarium wilt in this area.[2]

The seedbeds were prepared, using soil taken from portion of the field known to be heavily infested with nematodes. The seedbeds for Treatments 1 and 2 were fumigated with D-D thirty days prior to seeding. The field plots for treatments 1 and 3 were fumigated with D-D, using a hand injector thirty days prior to transplanting. Plots were raked, but not watered, immediately after treatment. To prevent contamination of fumigated plots all cultivation and weeding throughout the growing season were done by hand; a raised bank approximately six inches high surrounded each plot to prevent run-off of spray irrigation water.

At time of transplanting, 14th October, 1948, both groups of seedlings, from treated and untreated seedbeds, appeared quite healthy and showed no evidence of root gall formation.

Throughout the growing season plants severely infected with any disease other than root-knot nematode were removed. On six occasions plants were given a health rating using a rating scale from 0-10, healthy, vigorous plants being rated at 10 and dead plants at 0. Four pickings of fruit were made, the total yield of each plot being recorded. After the last picking the root system of each plant was examined for the presence of root galls and rated according to the severity of nematode attack, using a rating scale from 0-5 as illustrated in *Fig.* 1.

The mean health ratings for the four treatments throughout the growing season are shown in *Fig.* 2.

From *Fig.* 2 it will be seen that as the growing season progresses, there is a sharp decline in the vigour of the plants grown in untreated field plots (Treatments 2 and 4) as compared with plants grown in fumigated field plots (Treatments 1 and 3).

The mean yields and the severity of root gall formation for each of the four treatments are shown in *Table* 1.

*D-D is the trade name of an approximately equal mixture of 1-3 dichloropropene and 1-2 dichloropropane.

Fig. 1. Showing tomato roots rated 0-5 on root-knot nematode rating scale.

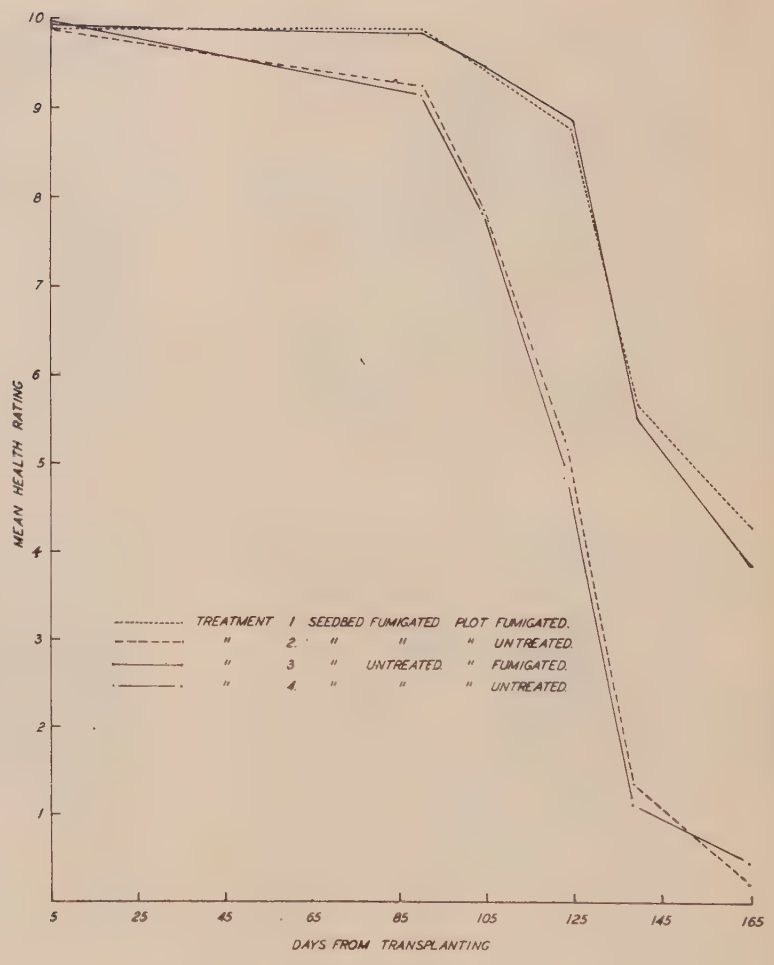
MEAN HEALTH RATING
DAYS FROM TRANSPLANTING
TREATMENT 1 SEEDBED FUMIGATED PLOT FUMIGATED.
" 2. " " " UNTREATED.
" 3 " UNTREATED. " FUMIGATED.
" 4. " " " UNTREATED.

Fig. 2.

Showing mean health ratings for the four treatments throughout the growing season.

TABLE I.

Showing mean yields and severity of root gall formation for each of the four treatments.

Treatment	Mean Yields (lbs./plant)	Mean Root Rating for Nematode Infection.
1. Seedbed fumigated. Plot fumigated.	9.167	0.095
2. Seedbed fumigated. Plot untreated.	2.784	4.769
3. Seedbed untreated. Plot fumigated.	8.746	0.869
4. Seedbed untreated. Plot untreated.	2.692	4.623
Min. diff. for significance at 5%.	1.309	

From *Table I* it will be seen that the plants grown in fumigated field plots (Treatments 1 and 3) have a significantly higher mean yield than the plants grown in the untreated field plots (Treatments 2 and 4).

Statistical analysis of the root ratings for nematode infection confirms that the difference between Treatments 1 and 3 and Treatments 2 and 4 is highly significant. The reduced gall formation in plants raised in fumigated seedbeds and transplanted to fumigated plots (Treatment 1) as compared with plants raised in untreated seedbeds and transplanted to fumigated plots (Treatment 3) is also significant.

This build up in the nematode population in a clean plot when the organism is introduced on infected seedlings is more clearly shown by an examination of the frequency of occurrence of the various rating classes for root gall formation as shown in *Table II*.

raised in untreated seedbeds and transplanted to fumigated plots (Treatment 3) only 55 per cent. of the plants showed no trace of nematode infection.

Discussion

From these results it will be seen that disinfection of the crop area is the most important factor in the control of the nematode. This has been shown by the maintenance of health and vigour as the season progresses, by the increased yield of fruit and by less root gall formation on plants grown in treated areas.

Seedbed treatment has been shown to be of no value where the seedlings are transplanted into areas already heavily infested with nematodes from the previous crop. However, the value of seedbed treatment when the seedlings are transplanted into clean or disinfected areas has been clearly shown by the increased amount of root gall formation due to the use of infected seedlings. These results illustrate the rapidity of population build up in suitable environmental conditions and the danger of spreading the disease in such areas by the use of contaminated seedlings.

TABLE II

Showing frequency of occurrence of the rating classes for root-gall formation in the four treatments.

Treatment	Number of Plants Rated.						Total
	0	1	2	3	4	5	
1. Seedbed fumigated. Plot fumigated.	160	7	3	1	—	—	171
2. Seedbed fumigated. Plot untreated.	—	—	1	6	22	122	151
3. Seedbed untreated. Plot fumigated.	92	31	22	17	4	1	167
4. Seedbed untreated. Plot untreated.	—	5	4	8	13	129	159

From *Table II* it will be seen that when the seedlings are raised in fumigated seedbeds and transplanted to fumigated plots (Treatment 1) 94 per cent. of the plants showed no trace of nematode infection. However, when seedlings are

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R. D. BROCK,
Division of Plant Industry,
C.S.I.R.O.,
Canberra, A.C.T.

J. E. GILES,
Commonwealth Research Station,
Merbein, Victoria.

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BLACKBERRY CONTROL USING 2:4:5-TRICHLORPHENOXYACETIC ACID FORMULATIONS

Two esters of 2:4:5-Trichlorphenoxyacetic acid have been successfully used by the New South Wales Department of Agriculture in blackberry control trials. Tests are still proceeding, emphasis being placed on time and rate of application, but results to date indicate that good control of blackberry can be expected by using these weedicides. Bushes sprayed in October, 1948, showed no sign of regrowth seven months later. In other trials, where lighter rates of application were used, regrowth did occur two months after spraying, but a further application killed this regrowth.

Trials are also in progress using 2:4:5-T derivatives on sweet briar (*Rosa rubiginosa L.*) lantana (*Lantana Camara L.*), bracken (*Pteridium aquilinum Kuhn*), and young growth of a number of *Eucalyptus spp.*

At the time of writing, 2:4:5-T is not available commercially, though it is expected that fairly large quantities will be available towards the end of the year.

A. JOHNSON.
Div. of Plant Industry,
Dept. of Agriculture,
New South Wales.

(*Received for publication, 2nd July*, 1949.)

OBSERVATIONS ON BROWN ROT OF STONE FRUITS IN FOUR SUCCESSIVE SEASONS IN FOUR CANBERRA SUBURBS

While engaged in investigating dieback of apricots in Canberra home orchards (averaging six trees in each) in the dry summer of 1946, extreme variation was noticed in the destructiveness of brown rot of stone fruits in adjacent trees. Apricots, *Prunus armeniaca* L. or peaches, *P. persica* Batsch, or nectarines, *P. persica* var. *nucipersica* Schneid. showing differences varying from less than five per cent. to more than ninety-five per cent. fruit infection with *Sclerotinia fructicola* (Wint.) Rehm., were sometimes within thirty yards of each other. The diseased and the almost healthy trees were usually within easy range of conidia of the organism from other trees in the same or adjacent orchards. The 1946-47 season was also dry, and because few trees bore, it was unsatisfactory for detailed investigation of the problem. The fruit on some trees was observed to be free from brown rot, whereas other crops in the vicinity were either almost, or altogether destroyed.

Most of the trees in the Canberra area bore heavily in the very wet 1947-48 season. Brown rot was widespread. Its incidence was observed on more than a thousand trees in about 200 home orchards that were repeatedly inspected during the bearing season. Observations were made of environmental factors, the variations of which were comparable to the differences in the incidence of disease in adjoining orchards. Twenty-one examples were recorded of pairs of apricot and peach trees, one of each pair losing most, or all of its fruit from brown rot, the other losing few, or practically none. Each member of a pair was of the same variety, and was within an average distance of thirty-seven yards from the other.

The great contrasts in disease incidence in adjoining orchards in dry as well as in wet seasons could not be correlated with weather conditions prevailing generally over the area, nor with modifications of weather conditions that might have been induced by the location of each individual tree, nor with differences in the habit of trees induced by pruning. Nor were the contrasts due to absence of inoculum in the trees bearing high percentages of healthy fruit and neither did they appear to be due to differences in spore load. Susceptibility was evidently not inherent in a variety, but was associated with some factor in the immediate environment of a tree.

Comparable data could not be obtained in the following dry season, because adverse conditions resulted in almost general failure of the trees to set fruit. However, in one home orchard, a budded peach that was free from disease in the previous wet year bore twenty per cent. of brown-rotted fruit; and an Elberta, on which the percentage of rotted fruit was twelve in the previous season, bore thirty per cent. rotted fruit. On a nectarine the corresponding percentages were ninety-eight and seventy-two.

The incidence of brown rot in Canberra appears to be influenced by the physiological status of the trees, which in turn depends largely on the local soil environment. Soils in the area vary greatly,

sometimes within a few yards, and the differences are accentuated by varying cultural practices. A small experimental orchard has been established to test the effect of soil management on brown rot.

H. R. ANGELL.
Division of Plant Industry,
C.S.I.R.O.,
Canberra, A.C.T.

(Received for publication, 2nd September, 1949.)

DISTRIBUTION IN AUSTRALIA OF THREE VIRUS DISEASES AND OF THEIR COMMON VECTOR OROSIUS ARGENTATUS (Evans)*

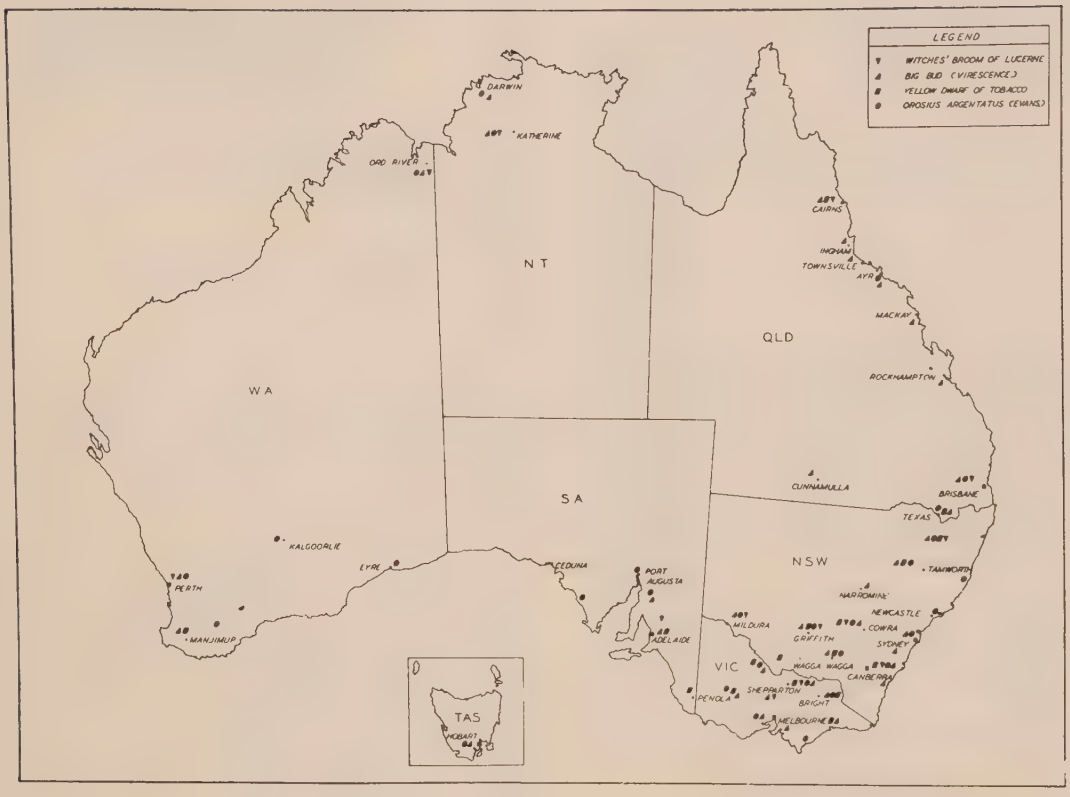
The occurrence of Yellow Dwarf of tobacco in Southern Queensland, New South Wales, Victoria and South Australia was reported by Hill and Allan.[5] It had also been observed at Mareeba, North Queensland, and at Manjimup, Western Australia. Virescence (Big Bud of tomato) occurs on tobacco, tomato and other species in all Australian states with the exception of Tasmania, where it has been observed only on plants other than tobacco and tomato. Witches' Broom of lucerne occurs in Queensland, New South Wales, Victoria, and South Australia.[1] It is also present in North Queensland, Northern Territory and Western Australia.

Recently it has been shown by Hill, [5, 6] and Helson, [2, 3, 4] that each of the three virus diseases, and the insect vector, has a wide host range. As yet, the distribution of Yellow Dwarf has been determined only by its occurrence on tobacco, and Witches' Broom by its occurrence on lucerne. Virescence has been observed, mainly on tobacco and tomato, but also on other host plants. Areas in which each of the three diseases has been observed by, or reported to, the writers are shown in the accompanying map.

Localities where the insect vector *Orosius argentatus,* occurs are also shown in the map, from which it will be seen that the jassid is widely distributed throughout Australia. The range extends from the moist tropics in the Northern Territory and Northern Queensland to the dry temperate regions in the south and west and it is present in every State of the Commonwealth.

The jassid is not only widely distributed in Australia but is also established throughout the Australian Region. According to Helson[3] it has been reported from Eniwetok, Ulithi, Guam, Larat, Amboina, Fiji, and Canton Island. Specimens, which are probably *O. argentatus,* are reported from Sunday Island in the Kermadec Group, New Zealand Region, and from the Philippines in the Oriental Region. Virescence has been reported from Java and Fiji, but there is no record of the disease or its vector from the main islands of New Zealand.

(*Formerly known under the name *Thamnotettix argentata* Evans.)



A. V. HILL,
Division of Plant Industry,
C.S.I.R.O.,
Canberra, A.C.T.

G. A. HELSON,
Division of Entomology,
C.S.I.R.O.,
Canberra, A.C.T.

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(*Received for publication 24th August,* 1949.)

DIGESTS

AGRICULTURE IN INDIA—With Special Reference to Plant Breeding

By B. P. PAL

India with a population of 320 millions has a pressing food problem. The increased production of food crops is all important.

Dietitians estimate that for an adequate standard of nutrition the following increases are needed:—

Cereals	10 per cent.
Pulses	20 per cent.
Fats and Oils	250 per cent.
Vegetables	100 per cent.
Milk	300 per cent.
Fish and Eggs	300 per cent.

Present Position

Indian agriculture is an intensive system of farming with small mixed farms of about five acres. Two or three crops per year are often grown on the one piece of land. Animal husbandry has suffered from the population pressure; long term pastures and adequate feeding are not possible.

Rice or "Paddy" is the most important of the many crops grown, next is wheat then millets, pulses, oil seeds, fibre crops, sugar cane and tobacco. The last two are "money crops," grown specifically for sale. Other crops are largely consumed by the peasants themselves. The average production is low (wheat 600 lbs. and rice 800 lbs. per acre), although there are areas of high production. Figures are not reliable, but production appears to have declined slightly in the last thirty years.

Farms are irrigated where possible, but most of India's agricultural lands are dry farming areas. There is very little mechanization. All cultivation is done with the wooden (steel shod) plough, the only standard equipment. The small size of the holdings and the superfluity of labour make mechanization generally impractical.

Organisation of Agricultural Services

Both the Central Government and the Provinces have agricultural services. The Central Government does the fundamental and national research and planning, while the Provinces do the extension work and tackle regional problems. Both carry on plant breeding work and co-operate therein; the varieties produced at Delhi are eventually distributed through the Provincial departments.

The staffs are large by our standards. The Delhi Division of Botany, i.e. Genetics, Cytology, Crop Physiology and Plant Introduction has more than thirty-six graduates on the staff and provincial organizations are correspondingly staffed. The top men usually have overseas training. Others are mainly graduates from the Central Research Institute at Delhi.

Methods of Increasing Production

The drive to increase production is along four main lines:

1. New Land. Estimated at 170 million acres available for cultivation, but most of it will be expensive and tedious to develop. Water is the limiting factor in many areas. New irrigation projects are

(From an address to the Victorian Branch of the Institute on 9th March, 1949. Dr. B. P. Pal is Joint Director of the Indian Agricultural Research Institute at New Delhi.)

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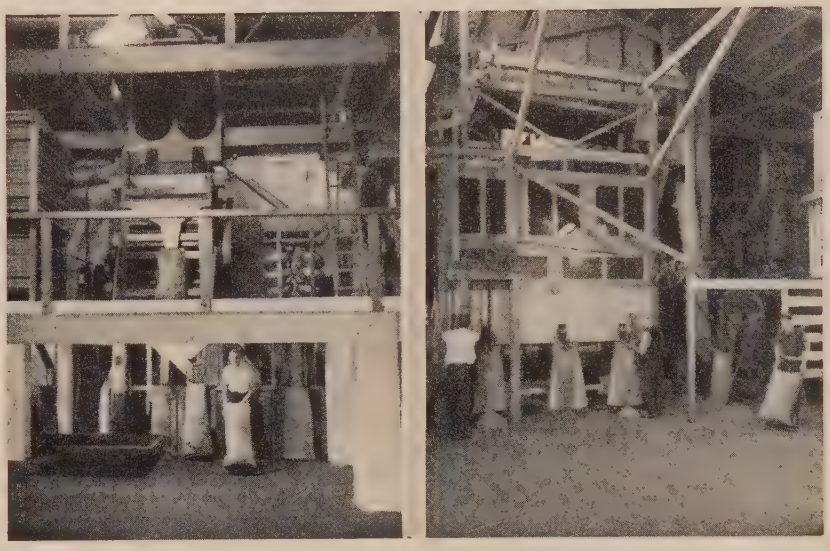

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being developed. (A considerable portion of the old irrigation area is now in Pakhistan.)

2. Increased Yields through Better Farming Practice. By using more fertilizer — this will give increases particularly in low yield areas and on worked out land, but there are many difficulties in its application. Soils lack Nitrogen and Phosphorus, but generally have sufficient Potassium. Farmyard manure is the main fertilizer; there is not nearly enough and lack of fuel necessitates its burning in many areas.

Composting has been developed, but unfortunately in those areas which need it most there is no vegetable refuse as this must be fed to livestock. Green manuring has not been very successful, particularly in drier areas where the ploughed in crop does not rot satisfactorily.

In some better watered areas, fertility can be restored by growing Egyption Clover for three years. This is fertilized with phosphorus and cut for hay. Then three or more good wheat crops can be grown. Water conservation is being encouraged with the building of dams, tanks and wells, and the better use of irrigation water.

The Central Government is testing and developing machinery for Indian conditions, though the small size of farms militates against this latter project. The Central Tractor Pool however is proving useful particularly in opening up new land for cultivation.

In the past work has been hampered by the lack of good soil surveys. The Central Government is now planning an overall land use survey.

3. Plant Protection. PATHOLOGY AND ENTOMOLOGY. These services are organized on orthodox lines with quarantine regulations, etc. The pathological work particularly is closely linked with the plant breeding programme.

4. Plant Breeding. Dr. Pal considered that this was the most practical way of helping the Indian farmer, since a small-sized farm did not in any way lessen the benefit derived from a higher yielding variety.

There are many workers in this field, both at Delhi and in the Provinces, but the number is not unduly large or even adequate when one considers the number of crops handled and the problems involved.

The Central Research Institute was established at the turn of the century at Pusa, but later moved to Delhi. The breeding work has been very successful and has made a really large contribution to Indian Agriculture. The well known Pusa wheats are examples. The Central Institute alone is now working on more than twenty-five crops, including wheat, maize, potatoes, tobacco, oilseeds, and vegetables.

Rice

This crop has a remarkably narrow range of adaptability. One variety may only grow well within a radius of five miles (there are more than 3,000 varieties grown in India). Because of this the main breeding work is done by the Provinces. Yield, quality and aroma are the characters required.

Wheat

The main wheat belt is on the Indo-Gangetic plain with 34 million acres grown on alluvial soil. It is sown November-December and harvested March to April. A good deal of wheat is grown in Central and Peninsular India; *T. durum* and a small amount of *T. dicoccum* are grown besides *T. vulgare;* some five per cent. of the total is grown in the hill regions.

The early breeding work was aimed at producing higher yield and better quality first by simple selection from the mixed crops then grown, and later by breeding. Australian parents have sometimes been used, notably Federation. This work has been largely successful and is still being carried out, but now the problem of disease is also being tackled.

Rust has proved a major problem, at times decimating the crop. There are

nine black rust races, seven brown and eleven yellow races, black rust being the only serious one in Central and Peninsular India. Professor Mehta proved that the summer heat on the Central and Southern plains destroyed all spores and hence that epidemics originated in the wheat grown in the northern hill country.

The first plan was merely to breed resistant varieties for this area, but this may not be a complete solution owing to the presence of alternative hosts, and further epidemics emphasized the need for a general rust breeding programme. This has been undertaken, foreign parents being used for resistance to produce local types resistant to the black rusts, types resistant to the brown rusts, and types resistant to the yellow rusts. These are now being crossed together to combine the resistances.

Intergeneric crosses have also been made with grasses for drought resistance and protein content, and intergeneric and interspecific genetical studies are in train with *T. vulgare* x *T. Vavilovi* and *T. vulgare* x *Aegilops caudida*. This last gave plants very similar to *T. sphaerococcum*, suggesting the possible origin of this species.

Oat and Barley breeding programmes are in train and recently the production of hybrid maize has been undertaken; at present they are testing imported inbreds in this regard.

Pulses are also important—a wilt resistant pigeon pea has been produced. This is now being crossed to improve its eating quality. Ciser is also affected by wilt, but unfortunately no highly resistant strains have been discovered.

The linseed breeding programme aims at combining the earliness of the local types with rust resistant Australian strains.

The cotton breeders are endeavouring to acclimatize the longer staple, better quality American cottons to the Indian environment. Their strains are not yet quite the quality of the American.

There is to be a special tobacco institute to be established on the east coast. The breeding aims are yield and quality. Strains have been selected from African types. The assessing of quality has proved very difficult.

The initial work with sugar cane has to be done at Coimbatore in Southern India, as many strains will not flower further North. Selection however is done in the local cane areas. The whole of India's successful cane growing which is in the northern sub-tropical belt is based on a cross with the grass *Saccharum spontaneum* from which was developed varieties sufficiently hardy for their conditions.

Vegetable breeding covering a number of crops is in progress. The berry tomato *Lycopersicum pimpinellifolium* has been used for its heat resistance. They have no frost resistant potatoes, but some less susceptible than others. *Brassica mutantsh* with closed flowers and without petals have been discovered, which will be useful in reducing out pollination.

Colchicine has been widely used to produce fertile interspecific crosses and to give larger fruited polyploid types. These have so far been somewhat sterile, but good progress is being made particularly with the Brassicas.

Selection is still done in the local areas, but they are now breeding wheat types specifically suited to higher fertility levels at New Delhi. The distribution of new seed, particularly cereals, was rendered difficult as the farmer was often in the hands of the merchant and had to buy and sell through him. However, farmers although conservative, did recognize the value of better varieties.

REVIEWS

PREGNANCY DIAGNOSIS TESTS — A REVIEW

By ALFRED T. COWIE

(Commonwealth Agricultural Bureaux Joint Publication No. 13, 1948, *pp.* 283. *Obtainable from Technical Bookshops or from C.A.B Liaison Officer,* 314 *Albert Street, East Melbourne, C.2. Price* 18/9.)

This publication is a valuable addition to the reviews of scientific literature. The author, Dr. A. T. Cowie, has surveyed all the important papers on the diagnosis of pregnancy in women and domestic animals with the exception of those concerned with clinical methods in women. The bibliography is very comprehensive and occupies 99 of the 283 pages. The chapter on clinical methods of pregnancy diagnosis very briefly summarises methods available to the veterinarian and recommends some of the more important papers for further study, but these would not be easily accessible to the practising veterinarian in Australia. The remaining 9 chapters deal with hormonal tests and enzymic and other biochemical tests of body fluids, as well as tests based on physiological and immunological phenomena and on physical investigations of body fluids and tissues.

The chief value of the book appears to be its completeness as a reference, especially for scientists newly undertaking investigations in these fields who can reassure themselves that they have not overlooked important contributions to a literature so voluminous that it becomes difficult to index new contributions and almost impossible fully to appreciate much of the earlier work.

A very useful paragraph on definitions and terminology is included which clarifies many difficulties encountered by the relatively uninitiated. The general adoption of such a terminology would render intelligible to those who are not specialists in the work terms in the literature which otherwise require an intimate knowledge of the development and history of the subject. The guidance given on the proper use of words relating to phases of the oestrous cycle such as oestrous, oestrus, meteostrus, dioestrus and anoestrus will be appreciated by those whose work touches this field and who experience difficulty in determining correct usage. It seems, however, that the title of the book would be more correct if it were changed to "Pregnancy Diagnosis" or "Pregnancy Tests."

T.S.G.

GROWTH SUBSTANCES AND THEIR PRACTICAL IMPORTANCE IN HORTICULTURE

By H. L. PEARSE

(Commonwealth Bureau of Horticulture and Plantation Crops Technical Communication No. 20, 1948, *pp.* 233. *Obtainable from Technical Bookshops or from the C.A.B. Liaison Officer,* 314 *Albert Street, East Melbourne, C.2. Price* 15/8.)

In this publication Dr. Pearse has brought up to date his review of information on the use of plant hormones published in 1939 as Technical Communication No. 12 of this series. This new review of the rapidly expanding knowledge of growth substances will be greatly valued by research workers and students in agricultural science as well as practical horticulturists and landholders interested in the application of this new knowledge.

The review deals with the history of the new developments adequately. The use of growth substances in vegetative propagation is covered in detail and is greatly strengthened by the inclusion of an index of 78 pages listing typical results obtained with cuttings of various species. Sections are devoted to the treatment of seed and seedlings and the treatment of growing plants. The use of growth substances in inducing parthenocarpic development of fruits is dealt with at length. The interesting results obtained with tomatoes and a number of other fruiting plants are described together with notes on other aspects of the use of these treatments. The chapter on the use of growth substances as selective weed killers is of particular interest to Australian agriculturalists generally. Questions of the prevention of sprout development in potatoes and the retardation of flowering to escape frost injury are comprehensively dealt with as well as other practical uses of growth substances. The text is supported by a comprehensive bibliography.

This review is a most valuable summary of world information on growth substances and their uses in 1948.

COUNCIL PROCEEDINGS

June Meeting

The 102nd meeting of Council was held at C.S.I.R.O., Canberra, on Tuesday, 7th June, 1949.

Present

Professor J. R. A. McMillan (in Chair), Dr. T. H. Harrison (A.C.T.), Mr. C. M. Donald (N.S.W.), Mr. C. H. Williams (S.A.), Dr. W. V. Ludbrook (Tas.), Mr. F. O. Grogan (W.A.), Mr. P. A. Reid (Vic.), Mr. C. G. Greenham (Qld.), the Honorary General Secretary (Mr. G. A. McIntyre), and the Honorary General Treasurer (Mr. W. Ives).

Institute Publicity

It was resolved "That the President be authorized to take steps to give press publicity to any agricultural matters of current general interest likely to further the interests of the Institute."

Rural Extension Services

State Branches are considering the questionnaire forwarded to Council.

Scholarship Report

It was resolved "That the report on facilities available to Agricultural workers to proceed overseas and gain experience with overseas workers be published in the Journal of the Institute."

C.S.I.R.O. Journal

The following resolution was adopted—"The Institute notes with considerable interest the decision of C.S.I.R.O. to sponsor the publication of a new Journal with the same format as the Australian Journal of Scientific Research and dealing specifically with Agricultural and Veterinary Science and requests that the Institute be consulted regarding policy, editorial constitution and the name of the Journal."

Delegates' Expenses to Annual Meetings

It was resolved—"That a sub-committee consisting of Mr. F. O. Grogan and Mr. W. Ives investigate the cost of alternative proposals for financing Delegates' expenses and report to Council at its next meeting."

Journal Business

On the recommendation of the Victorian Branch and the Publications Committee, Mr. P. T. Mitchell retained as a member of the Publications Committee, following his resignation as Assistant Business Manager.

Appointment of Dr. I. Clunies Ross

Council commended the President to convey to Dr. Ross, who is a member of the Institute, the congratulations of the Institute on his appointment as Chairman of C.S.I.R.O.

Referee Policy of the Institute Publications Committee

The Honorary Secretary was instructed to obtain from the Publications Committee a statement on the policy adopted with respect to the use of the referee principle.

Membership

ADMISSIONS

Having received the recommendation of the Branch submitting the application and of the Qualifications Committee, the following applicants were approved for corporate membership:—

Lewis, J. N.,	A.C.T.,
Morrow, J. E.,	A.C.T.,
Gates, C. T.,	N.S.W.,
Kynew, G. M.,	N.S.W.,
Meers, A. J.	N.S.W.,
Morschel, J. R. G.,	N.S.W.,
Potter, J. N.,	N.S.W.,
Smith, G. J. F. F.,	N.S.W.,
Watson, K. A.,	N.S.W.,
Allan, G. H.,	Qld.,

Bird, A. R.,	Qld.,
Nankivell, W. I.,	Qld.,
Oxenham, B. L.,	Qld.,
Rixon, A. J.,	Qld.,
Stern, W. R.,	Qld.,
Mattingley, G. H.,	Vic.,
Meagher, J. W.,	Vic.,
Shaw, D. D.,	Vic.,
Steele, L. J.,	Vic.,
Barrow, P. McK.,	S.A.,
Beck, M. B.,	S.A.,
Cant, R. R.,	S.A.,
Carter, E. D.,	S.A.,
Edwards, G. R.,	S.A.,
Kentish, T. D.,	S.A.,
Shirpurkah, G. R.,	S.A.,
Till, M. R.,	S.A.,
Trumble, H. P. C.,	S.A.,
Avent, K. L.,	Vic.,
Barley, K. P. S.,	Vic.,
Dunk, W. P.,	Vic.,
Erlich, S.,	Vic.,
Hishon, J. O.,	Vic.,
Jenkins, P. T.,	Vic.,
McMillan, R. B.,	Vic.,
Redrup, J.,	Vic.,
Simpson, Miss F. M.,	Vic.,

RESIGNATION

The resignation of Mr. N. C. Lloyd was received with regret.

STUDENT MEMBERS

Having received the recommendation of the Branch submitting the Application the following were admitted to Student Membership:—

Carter, M. V.,	S.A.,
Campbell-Smith, L.,	S.A.,
Smith, D. F.,	S.A.,
Roe, G. F.,	S.A.,
Richter, L. K.,	S.A.,
Richardson, J. M.,	S.A.,
McGlasson, W. B.,	S.A.,
Loveday, J.,	S.A.,
Kleinig, C. R.,	S.A.,
Hayman, D. L.,	S.A.,
Geytenbeck, P. E.,	S.A.,
Dolling, C. H. S.,	S.A.,
Clarke, A. L.,	S.A.,
Byrne, P. N.,	S.A.,
Dooley, M. H.,	Vic.,
Burton, M. V.,	S.A.,
Botham, J. R.,	S.A.,
Dodd, B. C.,	Qld.,
Sturgess, O. W.,	Qld.,
Moore, R. F.,	Qld.,
Hoey, C. A.,	Qld.,
Bertie, Miss R. P.,	Qld.,
Cossins, Miss S.,	Qld.,
Reilly, D.,	N.S.W.,
Simpson, R. L.,	N.S.W.,
Murty, D. W. P.,	N.S.W.,
Hutchinson, K. J.,	N.S.W.,
Mitchell, A.,	Vic.,
Lemaine, P. L.,	Vic.,

The Membership of the following Student members was *cancelled* by graduation:—

Phillips, K. H.,	N.S.W.
Evans, R.,	N.S.W.
Gallagher, T.,	N.S.W.

The cancellation of Student Membership of P. Feilen, recorded in the Minutes of Council, 5/4/49, has been nullified, as he is continuing a course of study.

August Meeting

The 103rd meeting of Council was held at C.S.I.R.O., Canberra, on Tuesday, 2nd August, 1949.

Present

Dr. T. H. Harrison (in Chair), Mr. W. Hartley (A.C.T.), Mr. C. M. Donald (N.S.W.), Mr. A. J. Anderson (S.A.), Dr. W. V. Ludbrook (Tas.), Mr. F. O. Grogan (W.A.), Mr. P. A. Reid (Vic.), Mr. C. G. Greenham (Qld.), and the Honorary General Secretary (Mr. G. A. McIntyre).

Salaries and Status

Dr. Harrison, as a member of the A.C.T. Branch sub-committee on the salaries and status of professional officers in the Commonwealth Public Service, presented an interim report to the meeting. As certain amendments are to operate in the very near future it was considered necessary to defer presentation of the report until these had been finally decided upon. The special feature of the Commonwealth Public Service is that architects, engineers, surveyors, draughtsmen, legal officers and scientists are at present on an equal footing.

It was reported to Council that this position of the profession in Western Australia was placed before the Farmers' Union in a letter comparing salaries of officers of C.S.I.R.O., the State Department of Agriculture and Engineers. Officials of the Union expressed concern at the existing position and would endeavour to effect improvements in the agricultural services and to assist the profession to rise to a level at least comparable with other professions.

The following resolution was received from the Western Australian Branch—"That this Branch suggests that Council as the Federal body make representations to all State Public Service Commissioners regarding improved salary and status for the Agricultural profession."

Rural Extension Services

A committee consisting of Messrs. Reid, Grogan and Donald was appointed to consider and, if necessary, collate the reports on rural extension services as received from Branches.

The New South Wales Branch repeated the request that Council should continue to investigate ways and means whereby the original plan to obtain a visit by an overseas authority on extension work might be implemented. Consideration was given to the matter and it was decided that the time was inopportune to make any further attempts along this line.

Articles of Association

It was resolved "That in light of consensus of opinion received from States in reply to questionnaire forwarded by Honorary General Secretary, a final draft of Articles of Association to be presented to the next General Meeting be prepared by the Secretary; such draft to be submitted to States for comment or further suggested alterations and to have attached comments already received from Branches on clauses not covered by the recent questionnaire."

C.S.I.R.O. Journal

It was reported that since the last meeting, a sub-committee of Council had conferred with representatives of C.S.I.R.O. and had presented a report to the Institute. on the proposed "Australian Journal of Agricultural Research."

After consideration of the views expressed by Branches the following motion was adopted—"That Council notes with appreciation that two members of the proposed Advisory Committee are Institute members not in C.S.I.R.O., and suggests that one of these be formally designated as the representative of the Institute and further that in the event of his retirement the Institute should be invited to submit a panel of names from which the Institute representative would be selected by C.S.I.R.O."

Finance

On the recommendation of the Hon. General Treasurer it was resolved to invest the sum of £300 in Commonwealth Bonds.

Payment of Honoraria

Council adopted the report of its sub-committee on the payment of Honoraria to Executive officers.

Membership

ADMISSIONS

Having received the recommendation of the Branch submitting the application and of the Qualifications Committee, the following applicants were approved for corporate membership:—

Robertson-Cuninghame, R. C.,	N.S.W.,
Gardner, F. J.,	N.S.W.,
Flint, S. E.,	N.S.W.,
Wyndham, Miss L. M.,	N.S.W.,
Fox, B. W. C.,	N.S.W.,
Rovira, A. D.,	Vic.,
Weymouth, P. K.,	Vic.,
Perry, R. A.,	A.C.T.,
Webber, R. T. J.,	S.A.,
Young, J. G.,	Qld.

Council decided that Mr. R. G. Shirpurkar, first overseas corporate member of the Institute, should be affiliated with the South Australian Branch.

CANCELLATION

On the recommendation of the N.S.W. Branch the Membership of A. Morris, who is no longer a member of the Faculty of Agriculture, Sydney, was cancelled.

TRANSFERS

The following transfers were noted:—

Mr. A. J. Millington—South Australia to Western Australia.
Mr. B. E. Butler—South Australia to New South Wales.
Mr. D. S. Thompson—South Australia to Tasmania.
Mr. W. D. Andrew—Victoria to Australian Capital Territory.
Mr. I. Molnar—Victoria to Australian Capital Territory.
Mr. R. A. Shewin—Tasmania to New South Wales.

SCHOLARSHIPS AVAILABLE FOR STUDY OVERSEAS

The following report* provides a list of Scholarships available in the Commonwealth of Australia for agricultural workers to gain experience abroad.

The scholarships, studentships and fellowships are listed under three subdivisions, namely, (1) those open throughout Australia to graduates of various faculties; (2) those open to graduates of various faculties or workers at specific universities; and (3) those restricted to graduates of Agricultural Science.

The lists do not include individual grants made sometimes by universities and the Council for Scientific and Industrial Research to officers travelling overseas on special leave, study leave, long service leave, etc. Likewise, special missions of individual officers who are sent overseas by their employers, whether Government or private, to study special projects have not been listed. For special individual applications, grants are made also from the Carnegie Foundation and the Rockefeller Foundation to enable or assist scholars to pursue certain courses of study, but these also have not been listed.

Scholarships open throughout Australia to Graduates of various Faculties

Rhodes Scholarships

Value: £400 stg. p.a. for degree course at Oxford University, supplemented at present by £100 stg. p.a. and half the sum by which cost of travel exceeds £50 stg.

Tenure: Two years, with extension to a third year if approved.

Persons Eligible: Students 19 to 25 years old who have completed at least two years of a degree course and shown qualities of leadership.

Number Available: One per annum at each of the six Australian State universities.

British Council Scholarships

Value: Up to £350 stg. plus fares.

Tenure: One year for study in the United Kingdom.

Persons Eligible: Candidates of graduates status or equivalent qualifications.

Number Available: Six per annum throughout Australia.

Exhibition of 1851

Value: £350 stg. p.a. plus allowances.

Tenure: Two years.

Persons Eligible: Graduates under 26 years of age who have shown superior capacity for scientific investigation.

Number Available: Two annually in Australia. Awarded by the Royal Commissioners for the Exhibition of 1851.

Commonwealth Fund (of New York) Service Fellowships

Value: To cover all costs incident to the holding of the Fellowship, including tuition, travel, equipment, and allowance of 200 dollars per month for single fellows. Married fellows have to satisfy Trustees that they can provide for their families.

Tenure: One year with renewal for a second academic year.

Persons Eligible: Advanced graduates in Government services under 35 years of age.

Number Available: Not more than 5 per annum for the British Empire, excluding Canada.

C.S.I.R.O. Studentships

Value: £500 p.a. to United Kingdom, plus all reasonable fares and fees. £700 p.a. to U.S.A. and Canada, plus all reasonable fares and fees.

Tenure: Two years.

Persons Eligible: Graduates who will return to Australia to join the staff of C.S.I.R.O. if required.

Number Available: Up to 30 studentships per annum, of which 12 are given in connection with the Wool Research Programme.

Science and Industry Endowment Fund Studentships

Value: £500 p.a. to United Kingdom, plus all reasonable fares and fees. £700 p.a. to U.S.A. and Canada, plus all reasonable fares and fees.

Tenure: Two years.

Persons Eligible: Graduates who will return to Australia to join the staff of C.S.I.R.O., if required.

** This report was prepared by Mr. A. C. T. Hewitt, Dr. H. C. Forster, and Professor S. M. Wadham, as a Sub-Committee of Council, acting in accordance with a resolution of the eleventh General Meeting.*

Number Available: Variable, but at present a total of two at any one time.

Nuffield Foundation Dominion Travelling Fellowships

Value: £600-£800 stg. p.a. exclusive of travelling expenses.

Tenure: One year for study in United Kingdom.

Persons Eligible: Australian nationals between 25 and 35 years, Master's or Doctor's degree, with at least one year of University teaching or research experience.

Number Available: Seven throughout Australia, two specifically for natural sciences.

Farrer Memorial Research Scholarship
(University of Sydney)

Value: £250 p.a. personal allowance, plus £150 p.a. cost of food and accommodation. Approved expenses as University fees, travelling, exchange, etc., will be paid from the Fund.

Tenure: One year from date of departure from Sydney. Scholar may be appointed for a second year if work satisfactory to Trustees.

Persons Eligible: Graduates of Australian Universities.

Number Available: One.

Sir John and Lady Higgins Scholarship
(University of Melbourne)

Value: £400 to £500 p.a., with expenses at the discretion of the Professorial Board, University of Melbourne.

Tenure: Two years.

Persons Eligible: Graduates in Science, Agricultural Science and Veterinary Science, who have done one year of post-graduate research, preference to be given to graduates in Agricultural and Veterinary Science, and to be for research into Industrial Chemistry and Biochemistry as related to Australian agriculture.

Number Available: One.

Remarks: It is not primarily a travelling scholarship, but can so be used.

Gowrie Post-Graduate Research Scholarships

Value: £500 stg. p.a.

Tenure: Two years abroad.

Persons Eligible: Post-graduates who are members or ex-members of the Forces during the 1939-46 war, and who had resided in Australia 12 months prior to enlistment, and children of members or ex-members of the Forces.

Number Available: Usually two.

Smithson Research Fellowship of the Royal Society

Value: £900 stg. p.a.

Tenure: Four years for Research in Natural Science at the University of Cambridge. The Fellowship may be renewed in exceptional circumstances for further periods of one year.

Persons Eligible: British subjects with outstanding ability, engaged on scientific investigations promising original results, and preference will be given to applicants under 35 years of age.

Number Available: One.

Beit Fellowships for Scientific Research

Value: £400 p.a.

Tenure: Two years at the Imperial College of Science and Technology.

Persons Eligible: Graduates under 25 years of age (of European descent) of any Faculty of a University of the British Empire.

Number Available: Not stated.

International Federation of University Women's Fellowships

Value: Usually of the order of 1,500 dollars.

Persons Eligible:

(1) Senior International Fellowships awarded to candidates between the ages of 28 and 45 years who have published results of independent research work.

(2) Junior Fellowships awarded to candidates who have been engaged in research work for at least one year, but who are not more than 28 years of age.

Number Available: Six throughout the world as far as known.

Remarks: Awarded for definite projects of a scholarly nature, and not for educational purposes, and candidates must be prepared to devote all their time to research work during the whole period of holding the Fellowships.

American Association of University Women's International Fellowships

Number Available:
One of 1,500 dollars per annum
One of 600 dollars per annum.

No further particulars available at present.

Senior Research Studentship, University of Manchester

Value: £300 stg., tenable at Ashburne Hall, University of Manchester. Available without age limit to a woman graduate of any British, American or Dominion University for one year.

Scholarships open to Graduates of various Faculties or Workers at specific Universities.

Graduates of University of Melbourne

Georgina Sweet Fellowship in Economic Zoology
Value: £500 p.a.
Tenure: One year with possible extension.
Persons Eligible: Graduates of University of Melbourne in Science, Agricultural Science and Veterinary Science, to conduct research to promote a branch of economic zoology in Australia.
Number Available: One when income from the fund permits.
Remarks: Not necessarily a travelling scholarship.

Aitchison Travelling Scholarship
Value: £350 p.a.
Tenure: One year and usually extended for a second year.
Persons Eligible: Male graduates of University of Melbourne of not more than two years standing.
Number Available: One.

Travelling Research Scholarships
Value: £350 p.a.
Tenure: Two years.
Persons Eligible: Graduates of Melbourne University who have shown first-class capacity for research.
Number Available: One or two.

Craig Travelling Scholarship
Value: £200 p.a.
Tenure: 1, 2 or 3 years at Queen's University, at Belfast. In exceptional cases, approval may be given to study elsewhere.
Persons Eligible: Graduates of University of Melbourne qualified to do research in animal husbandry.
Number Available: One.

Bartlett Scholarships
Value: £100 p.a., and scholarships may be held with others.
Tenure: One year, but may be extended to up to five years.
Persons Eligible: Graduates of the University of Melbourne.
Number Available: Eight annually.
Remarks: These scholarships are not primarily travelling ones.

A. M. White Scholarships
(Union Trustee Co. of Aust. Ltd.)
Value: Not more than £100.
Tenure: One year, and eligible for extension.
Persons Eligible: Protestant students and graduates of University of Melbourne engaged in research into diseases of sheep or other veterinary or agricultural subjects.
Number Available: Several.
Remarks: These scholarships are not restricted to travelling scholars.

Graduates of University of Sydney

Ben Fuller Trust Research Scholarship
Value: £300 p.a.
Tenure: Two years.
Persons Eligible: Graduates of Sydney University.
Number Available: One.
Remarks: Conditions in 1920 included travelling allowances of £100 or £150; scholar to pursue course of research abroad on some problems connected with the promotion of primary industries of New South Wales. Applications for this Scholarship were considered in 1946 after a gap since 1928 at which time the conditions were as above.

James King of Irrawang Travelling Scholarship
Value: £250 p a.
Tenure: Two years.
Persons Eligible: Awarded to a graduate of University of Sydney of not more than four years standing.
Number Available: One.

J. B. Watt Travelling Scholarship
Value: £250 p.a.
Tenure: Two years.
Persons Eligible: Awarded to a graduate of the University of Sydney of not more than four years standing.
Number Available: One.

G. H. S. and I. R. Lightoller Travelling Scholarship
Value: £250 p.a.
Tenure: Two years.
Persons Eligible: Awarded to a graduate of the University of Sydney of not more than four years standing.
Number Available: One.

Graduates of University of Queensland

Foundation Travelling Scholarships
Value: £250 p.a.
Tenure: Two years.
Persons Eligible: Graduates of the University of Queensland of not more than five years standing.
Number Available: Two.

Walter and Eliza Hall Travelling Scholarship
Value: £250 p.a., plus, at present, £50 for students working overseas.
Tenure: Two years.
Persons Eligible: Graduates of University of Queensland of not more than four years standing.
Number Available: One every two years.

Graduates of University of Western Australia
Hackett Research Studentships
Value: £200 p.a. with an additional allowance of £100 p.a. for such period as is spent outside Australia.

An allowance not exceeding £100 p.a. for books, and travelling may be paid for study in Australia, and £300 for the first year of study overseas, reduced to £100 for the second year of study overseas.
Tenure: Two years.
Persons Eligible: Graduates of University of Western Australia.
Number Available: Information not available.

Those restricted to Graduates of Agricultural Science
Imperial Chemical Industries Post-Graduates Scholarship in Agricultural Science
Value: £400 p.a.
Tenure: One year, but may be extended to three years.
Persons Eligible: Graduate in Agricultural Science of an Australian University.
Selection of Candidate: Faculty of Agriculture, University of Adelaide.
Number Available: One.

The Walter and Eliza Hall Agricultural Research Fellowship (University of Sydney)
Value: £300 annually. £200 for travelling and other expenses incidental to research.
Tenure: One year. Fellow eligible for reappointment from year to year.
Persons Eligible: Graduates in Agricultural Science of the University of Sydney of not more than five years standing.
Number Available: One.

Thomas Lawrence Pawlett Scholarships (University of Sydney)
Value: £300 p.a. £200 allowance for travelling abroad, which may be increased in exceptional circumstances by a further £200.
Tenure: One year. Scholar may be reappointed from year to year.
Persons Eligible: Graduates in Agricultural Science of University of Sydney.
Number Available: Two.

Free Passages.

Prior to the war, the major shipping Companies had a University Free Return Passage Scheme, whereby a number of berths were allotted to each Australian University on boats sailing during the off-season to take scholarship holders to the United Kingdom. These free return passages were discontinued at the outbreak of war, and although the shipping companies have not lost sight of the fact that they serve a very useful purpose, it is not known when consideration will be given to renewing them.

AWARD OF MERIT

The following remarks were made by Professor S. M. Wadham on the occasion of the presentation of the Australian Medal of Agricultural Science to Research Professor W. L. Waterhouse at the Thirteenth General Meeting of the Institute.

"Professor Waterhouse's career affords a splendid example of breadth of experience combined with singleness of purpose in research. After taking the Hawkesbury Diploma of Agriculture in 1906, he became headmaster of an Agricultural High School in Fiji for several years. He then returned to Sydney where he was awarded the B.Sc.Agric. degree and the University medal in 1914. In the following year he was awarded an "1851 Exhibition," but did not accept it because of the war. However, in 1918, he was appointed to a Walter and Eliza Hall Fellowship which enabled him to study at the Imperial College, London, and in the United States of America. On his return he set out on a career of research into the rust fungi which has been his main study ever since, and on which he has achieved such signal success.

"The scientific study of the rusts and of their importance in agriculture and human welfare is a long story in which the names of Marshall Ward and Erickson and later, Stakman, stand out prominently. Thanks to their initial research, the concept of physiological races and forms were developed. Building on this base Waterhouse made an exhaustive examination of the forms of *Puccinia graminis* which occur on wheat in Australia, and of the practicability of breeding resistant varieties.

"Applying his results he has produced new wheats which promise to be the most significant contribution to the progress of the industry since Farrer's time. In the northern section of our eastern wheat belt the effect which these new varieties may have is at present scarcely realised. In the southern section where rust is only a problem about one year in ten, the early reports on the yield of these varieties, such as Gabo, are very promising.

He has not confined his attention to the rust problem of wheat but has also studied them in flax, maize and barley.

Professor W. L. Waterhouse.

"In addition to these scientific achievements, Research Professor Waterhouse has been most interested in the botanical aspects of agricultural education, both in the University and in other spheres. He has been president of the Linmear Society of New South Wales, and of the Royal Society of that State. His distinction and services have been recognised by the award of a Doctorate in 1929, a Readership in 1943, and Research Professorship in 1946.

GENERAL

CHANGES IN C.S.I.R.O. EXECUTIVE

Sir David Rivett, K.C.M.G., M.A., D.Sc., F.R.S.

Sir David Rivett, who became Chairman of the Council for Scientific and Industrial Research in 1945, retired from that position in May, 1949. From 1926, when the Council was founded, until 1945, Sir David was Deputy Chairman and Chief Executive Officer.

After graduating at the Melbourne University, Sir David won the Victorian Rhodes Scholarship in 1907, and went to Lincoln College, Oxford. He continued his studies in Chemistry at the Nobel Institute, Stockholm, and returned to Australia to take up the post of senior lecturer in Chemistry at the University of Melbourne. He soon became associate professor and later professor.

In 1935, in recognition of his services the King bestowed on him the honour of Knight Commander of St. Michael and St. George. In 1941 he was elected a Fellow of the Royal Society. In 1946 Sir David led the Australian delegation to the British Commonwealth Scientific Conferences held in London.

During the first World War Sir David worked for the British Government on munition problems. His flair for research was recognised by the Australian Chemical Institute, which awarded him the first Henry Smith Memorial Medal in 1929. He was General President of this Institute in 1940 and again in 1949. He was President of the Australian and New Zealand Association for the Advancement of Science from 1937-1939, and in 1948-49 was President of the Society of Chemical Industries.

It is understood that Sir David will maintain his association with C.S.I.R.O. as Chairman of the new Advisory Council.

Dr. I. Clunies Ross, D.V.Sc.

The Chairman of the recently reorganised Commonwealth Scientific and Industrial Research Organisation which has replaced the C.S.I.R., is Dr. I. Clunies Ross, who became an Executive Officer of the C.S.I.R. in 1946.

Dr. Clunies Ross, after graduating in Veterinary Science at the University of Sydney, undertook specialized research in parasitology at the School of Tropical Medicine, London, and Cambridge University. Returning to Australia, he became Lecturer in Parasitology at the University of Sydney, and in 1926, C.S.I.R. parasitologist. In 1929-30 he carried out research at the Institute of Infectious Diseases, Tokyo, Japan. He then became Officer-in-Charge of the C.S.I.R. McMaster Animal Health Laboratory in Sydney. From 1937-1940 he was Chairman of the International Wool Secretariat in London, and was Professor of Veterinary Science at the University of Sydney from 1940-46. During the recent war he was Advisor on the Pastoral Industry for the Department of War Organisation of Industry and Director of Scientific Manpower.

Dr. Clunies Ross has had wide experience also in a number of other fields. He was a member of the Australian Delegation to the League of Nations Assembly in 1938, alternative Australian member of the Council of International Chambers of Commerce in 1939, a member of the National Research Council, a member of the Council of the Royal Agricultural Society of New South Wales, President of the Australian Institute of International Affairs 1941-45, and a member of the Senate of the University of Sydney.

PERSONAL

New South Wales

Dr. F. L. Milthorpe returned from England to take up the position of Plant Physiologist at the Waite Institute.

Mr. R. K. Morton has been awarded a Gowrie Research Travelling Scholarship and will work for two years at the Sir William Dunn Institute of Biochemistry at Cambridge on "Bacterial Metabolism in relation to milk quality." He held the Milk Board Research Fellowship in Bacteriology for three consecutive years in the Faculty of Agriculture at the University of Sydney.

Mr. E. S. Clayton has been appointed the first Commissioner of the Soil Conservation Service of New South Wales.

Dr. T. B. Kiely, Plant Pathologist in the New South Wales Department of Agriculture, has been awarded the degree of D.Sc.Agr. by the University of Sydney for his research on "Black Spot of Citrus."

Mr. G. J. Shanahan is working on external parasites of sheep and the newer insecticides at the Cooper Technical Bureau at Berkhamsted, Herts, England.

Mr. B. Doman has been appointed Principal of the newly-formed Wagga Agricultural College.

Queensland

Mr. N. E. H. Caldwell, formerly Assistant Director of Horticulture, has been appointed manager of the Chemical Division of Taubmans Q'ld. Pty. Ltd.

Dr. H. E. Young, latterly Senior Weeds Officer, and prior to that, Forest Pathologist, has commenced duty as Oidium Research Officer to the Rubber Research Scheme (Ceylon) and is working at the Agalawatta Research Laboratory.

Dr. N. T. M. Yeates has returned from Cambridge and has been appointed Research Officer with the C.S.I.R.O. He is working on beef carcase problems at the Brisbane abattoirs.

The following appointments have been made in the Queensland Department of Agriculture and Stock:—

Dr. W. A. McDougall has been appointed Senior Entomologist in the Department.

Mr. S. Marriott has been appointed Agrostologist in the Agriculture Branch.

Mr. B. Oxenham has been appointed Assistant Pathologist, Bureau of Sugar Experiment Stations.

Mr. A. F. C. Henderson has been appointed Assistant Soils Technologist, Horticulture Branch.

Mr. A. R. Bird has been appointed Agricultural Research Officer at the University of Queensland.

Victoria

Mr. P. S. Parsai, who recently returned home to India, has been awarded a Doctorate of Philosophy at Melbourne University for his work on "quick decline" of citrus.

Mr. R. A. Spicer recently took up an appointment with H. J. Heinz & Co. Pty. Ltd.

Miss Nancy Millis has been awarded a Scholarship at Long Ashton Horticultural Research Station where she will study a disorder of cider.

EDITOR'S APOLOGY.

The Editor regrets that it has been necessary to combine the September and December issues, and that publication has been delayed due to editorial difficulties.

Obituary

Dr. A. E. V. RICHARDSON

It is with sincere regret that we record the death in Melbourne on December 5, 1949, at the age of 66, of Arnold Edwin Victor Richardson, C.M.G., M.A., D.Sc., who has given such distinguished service to the profession of agricultural science in Australia.

Dr. A. E. V. Richardson.

Dr. Richardson was born in Adelaide, and after graduating at Roseworthy Agricultural College and the University of Adelaide, was appointed in 1909 as Assistant Director of Agriculture in that State. In 1911, he was invited to become Superintendent of Agriculture in the Department of Agriculture for Victoria for the specific purpose of placing the work of the Department on a sound scientific basis. He consolidated the research work of the Department by establishing stations in three main areas—the Central Research Farm at Werribee, the Experimental Farm at Rutherglen, and Longerenong Agricultural College.

The need for an equally sound basis in agricultural science education was recognised by him, and after visiting U.S.A. and Canada in 1918, Dr. Richardson submitted a report to the Victorian Government. As a result, the School of Agriculture was established at the Melbourne University on its present basis, and he was appointed the first Dean of the Faculty and Director of the School.

In 1924, with the establishment of the Waite Agricultural Research Institute by the University of Adelaide, Dr. Richardson returned to his native State as the first Director and Waite Professor of Agriculture. His vision and energy were responsible for making the Waite Institute the leading agricultural research centre of the Commonwealth.

In 1927, Dr. Richardson was appointed a member of the Executive Committee of the Council for Scientific and Industrial Research, and in 1938 became in turn its full time Deputy Chief Executive Officer and later, in 1946, its Chief Executive Officer, a post he held until his retirement in 1949. His outstanding personal qualities and wide knowledge of agriculture contributed largely to the successful research programme undertaken by the Council. In 1927, Dr. Richardson was a delegate to the first Imperial Agricultural Research Conference in London, and in 1932, an official adviser to the Australian Delegation to the Ottawa Conference. He was created C.M.G. in 1932. In 1947, Dr. Richardson was President of the Australian and New Zealand Association for the advancement of Science.

To the Australian Institute of Agricultural Science, A.E.V. will always be our inspiration. His genial personality and friendly spirit endeared him to us all. He was a foundation member and our first President, and his leadership and advice in the early years of the Federal Council were of the greatest value in welding together the several State branches into a Federal unit. May our profession of agricultural science always be a worthy monument to this great pioneer.

Commonwealth Agricultural Bureaux

PUBLICATIONS

The following is a list of journals of the Commonwealth Agricultural Bureaux, with subscription rates in English currency. For journals marked with an asterisk a 20 per cent. deduction is allowed to subscribers in the British Commonwealth who send subscriptions direct to C.A.B. Central Sales Branch, Penglais, Aberystwyth, Wales, Great Britain.

Bulletin of Entomological Research	40/–
Review of Applied Entomology (Series A)	40/–
Review of Applied Entomology (Series B)	20/–
*Review of Applied Mycology	40/–
*Soils and Fertilizers	35/–
Veterinary Bulletin	40/–
Index Veterinarius	100/–
Nutrition Abstracts and Reviews	63/–
*Plant Breeding Abstracts	35/–
*Field Crop Abstracts	35/–
*Herbage Abstracts	35/–
*Horticultural Abstracts	35/–
*Animal Breeding Abstracts	35/–
Helminthological Abstracts	35/–
*Dairy Science Abstracts	35/–
*Forestry Abstracts	45/–
Forest Products and Utilization	15/–

The C.A.B. Institutes and Bureaux operate as British Commonwealth centres for the collection and dissemination of information on all phases of agricultural research and production. The abstract journals produced by these centres give a complete world coverage of current literature in their particular fields. A function of the Institutes and Bureaux is to supply information, including bibliographies, on specific problem to research workers in the Commonwealth, on request.

In addition to the journals, reviews of subjects of current interest are produced in the form of technical communications. Recently published reviews of interest are:—

"The Use of Aerial Survey in Forestry and Agriculture" (1947). Price 9/5 (Aust).
"The Use and Misuse of Shrubs and Trees as Fodder" (1947). Price 11/3 (Aust.).
"Phenothiazine 1942-1946: A Review and Bibliography" (1948). Price 5/- (Aust.).
"Pregnancy Diagnosis Tests: A Review" (1948). Price 18/9 (Aust.).
"The Grasslands of Latin America" (1948). Price 25/- (Aust.).
"Growth Substances and their Practical Importance in Horticulture" (1948). Price 15/8 (Aust.).
"The Practice of Soil Conservation in the British Colonial Empire" (1948). Price 12/6 (Aust.).
"Diet in Relation to Reproduction and the Viability of the Young. Part I. Rats and other laboratory animals" (1948). Price 7/6 (Aust.).

These and all other technical communications published by the Commonwealth Agricultural Bureaux may be ordered through the C.A.B. Liaison Officer, 314 Albert Street, East Melbourne, C.2, Victoria.

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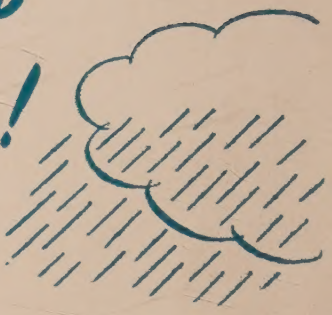

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